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(NASA-CR-168147) SATELLITE FIXED COMMUNICATIONS SERVICE: A FORECAST OF POTENTIAL DOMESTIC DEMAND THROUGH THE YEAR 2000. VOLUME 3: APPENDICES Final Report (Western Union Telegraph Co., McLean, Va.) N83-34115

Unclas

G3/32 36057

SATELLITE PROVIDED FIXED COMMUNICATIONS SERVICES: A FORECAST OF POTENTIAL DOMESTIC DEMAND THROUGH THE YEAR 2000

FINAL REPORT - VOLUME III - APPENDICES

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NAS3-23255

AUGUST, 1983

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CR-168147	--------------	---------------

4. Title and Subtitle	5. Report Date
Satellite Provided Fixed Communication Services: A Forecast of Potential Domestic Demand Through the Year 2000	August, 1983
	6. Performing Organization Code ---------------
7. Author(s) D. Kratochvil, J. Bowyer, C. Bhushan, K. Steinnagel, D. Kaushal, G. Al-Kinani.	8. Performing Organization Report No. ---------------
	10. Work Unit No. --------------
9. Performing Organization Name and Address The Western Union Telegraph Company Government Systems Division McLean, VA 22102	11. Contract or Grant No. NAS3-22894
	13. Type of Report and Period Covered Vol. III - Appendices
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Lewis Research Center Cleveland, OH	14. Sponsoring Agency Code -----------------

15. Supplementary Notes

NASA Project Manager: Steven M. Stevenson

Two other Volumes were also prepared: Volume I - Executive Summary, Volume II - Main Text

16. Abstract

The overall purpose of this study was to forecast the potential United States domestic telecommunications demand for satellite provided fixed communications voice, data and video services through the year 2000.

To accomplish this purpose the following objectives were achieved:

a. Development of a forecast of the total domestic telecommunications demand

b. Identification of that portion of the total demand suitable for transmission by satellite provided fixed communications systems

c. Estimation of the actual amount of traffic that could be captured by Ka-band systems.

The approach employed included the use of a variety of forecasting models, a parametric cost model, a market distribution model and a network optimization model. Forecasts were developed for: 1980, 1990, and 2000; voice, data and video services; terrestrial and satellite delivery modes; and C, Ku and Ka-bands.

ORIGINAL PAGE IS OF POOR QUALITY

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Telecommunications Forecast Satellite Telecommunications Fixed Communications Services Traffic Demand	Unclassified

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	419	

* For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA-C-168 (Rev. 10-75)

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APPENDIX A
BASELINE FORECAST

A.1 INTRODUCTION

The baseline forecast is a projection of the current and future volume of traffic. Every service must be examined with regard to its own unique past and future, taking into consideration only those events with a high probability of occurrence.

A number of factors were taken into consideration in determining the baseline forecast:

a. The difficulty in determining both the current traffic volume and future traffic volume for 1990 and 2000
b. Defining the services so that all traffic in the United States is included, but none counted twice
c. Predicting traffic volume is further compounded by machines operating at various speeds and using different transmission media, such as digital and analog.

Given these factors the following approach was used to derive a baseline forecast for each of the thirty-one services for 1980, 1990 and 2000.

The first step in determining the baseline forecast was to clearly define each of the services. A review of the current literature and discussions with various vendors provided information for refining service descriptions and characteristics. These same sources were used to make future projections and thus understand the changing and developing service definitions. In order to remain consistent, our definitions were compared and altered to be as compatible as possible with those used in an earlier (1) study. A summary of the changes made since this earlier study are indicated in Table A-1 and the names of the 34 services considered in this study are listed in Table A-2; it should be pointed out that forecasts were developed for only 31 of these 34 services.

Once the services were defined, it was necessary to determine the method to be used to derive the baseline. Basically, this step consisted of gathering available

TABLE A-1.
SUMMARY OF CHANGES MADE IN THE NAMES OF THE SERVICES

Combined:

These Services	Called Them
Data Transmission (Part) Data Entry	Data Entry
Data Transmission (Part) Electronic Funds Transfer Inquiry/Response	Inquiry/Response
Private Timesharing Commercial Timesharing	Timesharing
Operational Facsimile Convenience Facsimile Special Purpose Facsimile	Facsimile

Deleted

Packet Switching

Added

Direct Broadcast Satellites
High Definition Television
Voice Store-and-Forward
Video Recording Channel
Point of Sale

Split-Radio

Public Radio
Commercial and Religious Radio
Occasional Radio
CATV Music
Recording Channel

TABLE A-2. NAMES OF SERVICES CONSIDERED IN THIS STUDY

	GROUPING	SERVICE
VOICE	Message Toll Service	Residential Business
	Other Telephone	Private Line Mobile Radio *Voice Store-and-Forward
	Radio	Public Commercial and Religious Occasional CATV Music Recording Channel
DATA	Terminal Operations	Data Transfer Batch Processing Data Entry Remote Job Entry Inquiry Response Timesharing
	Electronic Mail	USPS EMSS Mailbox Services Administrative Message Traffic Facsimile Communicating Word Processors
	Record Services	TWX/Telex Mailgram/Telegram/Money Order
	Other Terminal Services	Point of Sale Videotex/Teletext Telemonitoring Secure Voice
VIDEO	Broadcast	Network Video CATV Video Occasional Video Recording Channel
	Limited Broadcast	Teleconferencing *DBS *HDTV

*Forecasts were not developed for these services which were treated as market determinant factors.

information from user surveys, industry analyses, magazines, and internal sources for each service. Other studies, including the two original trunking studies, (1,2) also were reviewed to determine how others projected traffic demand. Using this information, the basic approach and necessary steps to determine a baseline for each service was determined. This approach was based largely on: historical information (such as telephone traffic); future volume of the machines producing the traffic (such as computer terminals for data traffic); or on the future volume of the actual service (such as electronic mail). The most appropriate basis was selected for developing the baseline for each service. In some instances, this differed from the approach taken in the first study. For instance, in this study television traffic was projected for actual satellite usage; previously, the amount of traffic throughout the U.S. was determined.

Once the technique for forecasting the baseline was determined for each service, a detailed analysis was conducted. Vendors and users were contacted, the most recent industry studies were obtained, and government agencies were visited. The particular steps used to determine the forecast are given under the discussion of baseline for that service. After deriving the baseline, it was discussed with Western Union Product Line Managers, Engineers, and Market Researchers; their feedback was used to fine tune the projections.

As indicated in Table A-2, besides the thirty-one basic services, three other services were considered: voice store-and-forward, Direct Broadcast Satellites (DBS) and High Definition Television (HDTV). Voice store-and-forward is not actually a new service, but rather a way of aiding the business message telephone service. Therefore it was treated as a market determinant factor, and its effect shows up in the impacted baseline. DBS and HDTV are unique services and were discussed together. A forecast of these services was not made, however, since the 1983 World Administrative Radio Conference (WARC) and the FCC are very likely to allocate a separate area of spectrum outside the C-, Ku- or Ka-bands normally used. It is likely that these services will have an impact on other video services, therefore, they were treated as market determinant factors.

A.2 VOICE APPLICATIONS

The most widely used services fall within the voice categories. There are several reasons for this. First, almost everyone and every business has a telephone. Second, there are no standardization problems as there are with data or video, so it is easy to use. Third, it requires very little bandwidth to transmit a high quality signal, so it is a relatively cheap way to communicate.

Voice applications are grouped, as follows, into three sections: message toll service, telephone and radio.

Message Toll Service	Residential Business
Other Telephone	Private Line Mobile Radio Voice Store-and-Forward
Radio	Public Commercial and Religious Occasional CATV Music Recording Channel

The message toll service and telephone sections deal with all regular telephone conversations. Much of the information used in these projections came from AT&T tariff filings as well as historical information filed by all the independent phone companies. Mobile Radio, which is commonly thought of as a car telephone, is undergoing drastic changes as the FCC permits use of cellular radio. The information used to project mobile radio traffic came from FCC filings and internal company studies.

Radio traffic is made up of AM, FM, and a few other subservices; the current trend is toward networks and national programming. The information to project current and future traffic is based on FCC filings and actual plans for use of transponders.

Traffic units for voice are stated in half-voice circuits. This unit is one half of a telephone conversation. For the sake of consistency, radio traffic is also stated in half-voice circuits.

A.2.1 Message Toll Service

Message Toll Service (MTS) is basically a metered switched service used by both residential and business sectors. Residential MTS includes both typical household and coin operated categories of metered switched service as provided by the Bell system and other independent telephone operating companies. Business MTS includes regular business service and Wide Area Telephone Service (WATS).

Metered switched service works by monitoring the time two parties are on the line and charging the call to the calling party. WATS is a long distance dial-up service offered by AT&T Long Lines and other Bell Operating Companies to and from specified zones. Five zones of coverage are provided at various tariffs.

There are two types of WATS service: 800 service (in-WATS) and out-WATS. 800 service is an inbound service, permitting the user to be called at no charge to the calling party. The receiving party subscribes to the service. With out-WATS, the call originator is connected to the WATS line and may call any subscriber within the specified zones.

A.2.1.1 Baseline

The baseline for message telephone traffic is determined by using extensive FCC statistics along with studies completed by AT&T. The basic approach (see Table A-3) starts with the number of toll messages handled in the United States during 1980: 21,832 million. This statistic is available from the FCC form 81-1, "Quarterly Operating Data of 68 Telephone Carriers."(3) To this, a ratio of business to residential calls was determined (55:45) "Bell System Operating Companies: Summary of Reports" (Form D-618) which provided the average number of calls per business and residential phone. After splitting the traffic, the business and residential traffic is divided by the number of days they are used. The peaking factor, as determined by AT&T, is then applied (see Reference 9). The next step is to ascertain the amount of inter and intrastate

TABLE A-3

BUSINESS/RESIDENTIAL MTS 1980

	Business		Residential	
Number of toll messages: 21,832M				
Split		55%		45%
Toll messages		12,007.5M		9,824.3M
Percent of messages occurring between Sunday midnight and Friday midnight		98%		67%
Messages during normal work week (entire year)		11,767.4M		6,582.3M
Work days per year		250		250
Messages per work day		47.070M		26.329M
Percent during peak hour		14.9%		10.7%
Messages during peak hour		7.013M		2.817M
Interstate/intrastate split	60%	40%	40%	60%
Calls	4.208M	2.805M	1.127M	1.690M
Call-minutes/hour	.123	.085	.123	.085
Erlangs	.518M	.2384M	.1386M	.1437M
Half-voice circuits	1.0352M	.4769M	.2772M	.2873M
Half-voice circuits		1.521M		.5645M
Half-voice circuits needed for .9999 service availability		1.588M		.5930M

traffic. Again, the FCC's "Statistics of Common Carriers" provided revenue data. By doing some internal analysis using tariffs, a percentage for each type of traffic (60:40 for business; 40:60 for residential) was determined. The average holding time determined for each type of traffic as shown in an AT&T report "Holding Times", is then applied. To the holding time a factor is added for transmission overhead, obtained from a Bell System Technical Report[4]. Once the traffic was in Erlangs an estimate of the number of trunks (half-voice circuits) needed to provide a .9999 service availability was established. This involved separating the traffic into its different city pairs. Since this was impractical an estimate of the overall percent of trunks was made based on Erlang tables (5 percent was used).

Historical FCC data, along with internal information, was used to arrive at the following projected growth rates for business and residential toll messages (see Reference 10).

MESSAGE GROWTH RATES (%)	1980 to 1990	1990 to 2000
Business	10	8
Residential	8	7.5

No data was available to indicate a change in peaking factors or percent of interstate versus intrastate traffic. Holding times seem to be increasing slightly. Progress is being made on reducing overhead per call; therefore, the holding time plus the overhead was held constant. Based on these projections, it was possible to project the number of half-voice circuits required in 1990 and 2000 for message toll service (see Tables A-4 and A-5). A summary of the 1980, 1990 and 2000 forecast is presented in Table A-6.

A.2.2 Other Telephone

Three other services are telephone related and are therefore grouped. They are: private line, which is the leasing of a circuit; mobile radio, which is a car telephone; and voice store and forward, which is similar to a mailbox for telephone calls.

TABLE A-4
BUSINESS MTS

	1990		2000	
Messages per year		31,144.4M		67238.4M
Percent between Sunday midnight and Friday midnight		98%		98%
Messages during work week (entire year)		30521.5M		65893.6M
Work days per year		250		250
Messages per work day		122.1M		263.6M
Percent during peak hour		14.9%		14.9%
Messages during peak hour		18.19M		39.27M
Interstate/intrastate split	60%	40%	60%	40%
Calls	10.914M	7.276M	23.562M	15.709M
Call-minutes/hour	.123	.085	.123	.085
Erlangs	1.342M	.618M	2.898M	1.335M
Half-voice circuits	2.685M	1.237M	5.796M	2.681M
Half-voice circuits		3.922M		8.467M
Half-voice circuits needed for .9999 service availability		4.118M		8.890M

TABLE A-5
RESIDENTIAL MTS

	1990		2000	
Messages		21209.9M		43174.3M
Percent of messages occurring between Sunday midnight and Friday midnight		67%		67%
Messages during work week (entire year)		14210.6M		29288.6M
Work days per year		250		250
Messages per work day		56.8M		117.15M
Percent during peak hour		10.7%		10.7%
Messages during peak hour		6.08M		12.54M
Interstate/intrastate split	40%	60%	40%	60%
Calls	2.43M	3.65M	5.02M	7.52M
Call-minutes/hour	.123	.085	.123	.085
Erlangs	.299M	.310M	.617M	.639M
Half-voice circuits	.598M	.620M	1.234M	1.279M
Half-voice circuits		1.218M		2.513M
Half-voice circuits needed for .9999 service availability		1.279M		2.639M

TABLE A-6

MESSAGE TOLL SERVICE TRAFFIC FORECAST—HALF-VOICE CIRCUITS

(thousands)

SERVICE	YEAR 1980	1990	2000
Business MTS	1588	4118	8890
Residential MTS	593	1279	2639

A.2.2.1 Private Line

Private lines are dedicated transmission lines connecting two points. They are leased through AT&T and other telephone companies on a monthly or yearly basis. In the last few years, the FCC has allowed others to enter this market. These companies often discount the most heavily used routes, capturing a larger share of the market each year.

A.2.2.1.1 Baseline

Since private lines are leased full time, there is little need to determine the amount of traffic carried by them as has been done for other services. Instead, the important factor is the number of lines leased.

To determine the number of lines leased (see Table A-7) the revenue for toll private lines from the "FCC's Quarterly Operating Data of 68 Telephone Carriers" (3) was used. This number includes private line revenue from sources other than telephone useage. Based on internal discussions it was concluded that 70 percent of the revenue was from private line telephone. To this an estimate of the additional market held by companies other than the 68 telephone carriers was added. According the consultant studies this currently stands at 15 percent and is growing. Because of the tariffs used (1980) the figures in this report were adjusted.

After determining the revenue, it was split between interstate and intrastate (see Table A-7). This was done using the tariffs and Western Union's own experience. The split was determined to be 72% interstate and 28% intrastate.

The next step was to use an average tariff for both interstate and intrastate to determine the average number of circuits leased during the year. For this FCC Form 260 was used. The charge for a 100-mile interstate line, including station terminal equipment, was determined to be $8,500 per circuit per year. For intrastate, an average tariff for 1,000 miles including station terminal equipment was determined to be $15,000 per circuit per year.

TABLE A-7

PRIVATE LINE
(thousands)

Revenue	$ 3,874,545
Percent contributed to telephone	70
Revenue (Telephone Companies)	2,712,181
15% Revenue (Other Carriers)	426,827
	$ 3,139,008

	INTERSTATE	INTRASTATE
Percent	72	28
Revenue	2,260,085	878,922
Tariff Rates		
Average number of miles	1.0	.1
Rate	12.3	4.5
Circuits in 1981	183.7	195.3
Circuits in 1980	156.2	166.0

Reviewing the rapid increase in competition to provide MTS service and the changes in tariff rates, it was expected that the growth rate for private line service will be around 15% during much of the 1980s [5] gradually falling off at the end of the decade to an average of 10% in the 1990s. A summary of the interstate and intrastate private line forecasts are presented in Table A-8.

A.2.2.2 Mobile Radio

Mobile radio telephone is a service connecting the public switched telephone network to mobile units. Bell Telephone operating companies and other radio common carriers provide the service. Conventional mobile radio telephone uses a single high powered transmitter to cover a service area. Because the signal level of each channel in the area is high enough to cause interference, each channel can only support one conversation within a given service area.

The application of cellular technology, however, will alleviate this congestion, which has suppressed growth in the mobile radio market. In cellular systems, the service area is divided into smaller regions (cells) served by several low power transmitter/receiver sites. Radio channels used in one cell can be reused in another cell a short distance away. Consequently, a given channel can be used simultaneously for many conversations in a single service area. In experiments conducted in Chicago and in the Baltimore/Washington Area, users of cellular radio have been found to use the service three to four times longer than conventional mobile telephone customers. Users have found they don't have to wait to place calls and the quality has been termed "far better" than the conventional system.

Progress in the mobile telephone market had been slowed due to the indecision of the FCC in adopting standards. However, with the recent experiments already mentioned and the setting of 900 MHz as the frequency for cellular phones, the mobile telephone market is just warming up. A possible scenario for nationwide coverage is a conventional cellular system in urban areas augmented by satellite service in rural areas.

TABLE A-8
FORECASTS OF INTERSTATE AND INTRASTATE PRIVATE LINE TRAFFIC (THOUSANDS OF HALF-VOICE CIRCUITS)

SERVICE	YEAR 1980	1990	2000
Interstate	312.4	1263.8	3278.0
Intrastate	332.0	1343.1	3483.7
TOTAL	644.4	2606.9	6761.7

A.2.2.2.1 Baseline

Recently, there has been a great deal of interest in the mobile radio market. Numerous studies [6,7,8] have been done by AT&T, Motorola, MCI, Western Union and others in support of their tariff filings (these may be obtained at the FCC). Filings for the top 30 cities are currently at the FCC and we have reviewed much of the marketing information. In addition, Western Union has gathered a great deal of information by having filed either along with or as a partner in 15 of the top 30 markets. This has involved a large market survey and extensive research in those markets. Western Union, along with dozens of other companies, is currently preparing filings for other cities.

Based on the information from these sources, it was possible to estimate the number of mobile phones in 1980, 1990 and 2000 (see Table A-9). Using the Western Union market analysis for Kansas City, the projected average number of calls per day is three per phone. This number can be expected to rise over time, but just slightly (B). This times the number of phones gives the number of calls per business day (C). Applying the peaking factor (D) based on Western Union's internal analysis, gives the number of calls during peak times (E). Average holding time per conversation is currently 2.5 minutes. Using the results of the Chicago and Baltimore/Washington tests, one could expect this figure to rise to 6.4 minutes by 1990 and seven minutes by 2000, which is much closer to the use of the average business telephone (F and G). Multiplying this gives the number of Erlangs (H). The ratio of phone calls between large and small systems was made based on an internal estimate. The number of systems was also projected to grow (J). The 1980 numbers are based on the FCC requesting applications for the first 30 cities and then the next 100. Multiplying the percent of traffic times Erlangs gives Erlangs by large and small systems (K). Dividing by the number of cities in each system gives the number of Erlangs per city (L). Using the "Trunk-Loading Capacity --Full Availability Tables" and a service performance of .05 gives the number of duplex trunks needed to handle the traffic in each city (M). Multiplying by the number of cities in the system gives the total number of trunks required (N). Estimates of the percentage of long distance traffic ranged from 10 to 25% of total traffic; 18% was chosen as a reasonable estimate (O). Multiplying the percent of long distance traffic by the number of trunks required gives the number of long distance trunks required.

TABLE A-9
MOBILE RADIO TRAFFIC FORECAST

	All Systems		
	1980	1990	2000
A. Phones	158K	1,600K	3,900K
B. Calls per phone	3	3.5	4
C. Total calls	474K	5,600K	15,600K
D. Percent peak hour	15%	15%	15%
E. Calls during peak	71K	840K	2,340K
F. Holding time plus overhead	2.5	6.4	7.0
G. Holding time - minutes per hour	.042	.108	.117
H. Erlangs	2,986	90,720	273,780

	Large Systems			Other Systems		
	1980	1990	2000	1980	1990	2000
I. Percent of traffic	67	67	67	33	33	33
J. Number of systems	30	40	50	100	125	150
K. Erlangs	2,001	60,782	183,433	985	29,938	90,347
L. Erlangs per city	66.7	1,520	3,669	9,85	240	602
M. Trunks needed per city	73	1,600	3,815	16	263	640
N. Total trunks	2,190	64,000	190,750	1,600	32,875	96,000
O. Long distance	18	18	18	18	18	18
P. Long distance trunks required	394	11,520	34,335	288	5,918	17,280

	1980	1990	2000
Large	394	11,520	34,335
Small	288	5,918	17,280
TOTAL	682	17,438	51,615
Half-Voice Circuits	1,364	34,876	103,230

Table A-9 gives the number of full duplex trunks needed for each type of system. This number times two gives the number of half-voice circuits required for 1980, 1990 and 2000.

A.2.2.3 Voice Store-and-Forward

Voice store-and-forward, a computerized storage-retrieval system for distribution of voice message communications, is one of the features of the "office of the future" which is here now.

Voice store-and-forward is similar to its text counterpart, electronic mail, in that messages are stored in digital form for convenient delivery at a later time. With voice store-and-forward the user simply dictates the message over the telephone instead of typing it. Ultimately, voice store-and-forward will be integrated with its text counterpart to form an integrated messaging system.

Each user of the system is assigned a "mailbox" which stores voice messages from other users in digital form. To retrieve their messages, users simply call the system from any keypad-equipped telephone. After hearing the message, a user may reply immediately and the system will automatically deliver the response to the original caller.

Following is a partial list of vendors supplying voice store-and-forward systems:

a. ECS Telecommunications - "Voice Message Exchange" (VMX)
b. Solid State Systems - "Voice Storage System"
c. Honeywell/Action Communications - "Watsbox"
d. IBM - "Audio Distribution System" (ADS)
e. Wang Labs - Digital Voice Exchange (DVX)
f. Dialcom, Inc. - "Intercomm"
g. BBL Industries - "Voice Mail System"

Equipment and services for store-and-forward message systems are expected to grow at an annual rate of 45% through 1990; the greatest growth will occur in the area of Voice Store-and-Forward Message (VSFM) systems. Beginning around

1985, medium to large-sized businesses will begin to utilize VSFM services integrated with new or pre-existing PABX systems.

According to ECS Telecommunications representatives there are now more than 22,000 users of voice mailboxes throughout North America, and in the first year and a half more than ten million voice messages have been sent. As an inducement to buy their product, ECS Telecommunications Company is offering access via a free 800-number from any user to pilot test their voice mailbox service.

One of the larger users of Voice Message Exchange (VMX) services is the Westinghouse Corporation. Presently, they have 900 professionals and managers using their voice mailbox system. Users are located at Westinghouse facilities around the country and the globe. Nearly 70% of the users employ the service regularly, sending an average of two voice messages per day. Many employees use VMX to leave voice messages as reminders to themselves; others use it to broadcast messages to all staff members within a group. It is reported they now conduct approximately 20 to 25% of their interoffice communications through the Voice Message Exchange. Prior to VMX, "Regular telephone calls averaged five minutes, VMX calls now average just 1.5 minutes," according to the Westinghouse Manager of Communications.

Voice store-and-forward systems will become integral part of business telecommunications. Therefore, instead of determining the amount of traffic which it will eventually generate, it was decided to treat it as a market determinant factor under voice applications affecting business message telephone traffic.

A.2.3 Radio Services

Satellite transmission of radio programming has seen an explosion over the last five years. This growth occurs as existing networks switch to satellite distribution and the number of networks increases to meet listener demand. Satellite distribution will continue to grow because economies of production and emergence of new radio stations will increase the demand for network programming. The prospect for growth in radio program transmission is very good in the near future and continues to be good through the end of the century.

The demand for radio networks results from a variety of economic, technical and regulatory factors. The number of radio stations has more than doubled between 1968 and 1978; from 4,000 to over 8,500 stations. This movement is likely to continue as the FCC takes actions which increase the number of stations any one market can have and as more markets become saturated. The introduction of new services such as AM Stereo, CATV all music channels and recording channels will also spur the formation of new networks.

Perhaps the biggest push for national networks will come from the desire to segment the market. Public radio, with its plans to go to 24 channels, is doing this now. More religious stations will pool their resources to market to their respective audiences. The National Black Network is aiming at a segment. A review of other channels reveals the Wall Street Journal's "Reports", "Beautiful Music," "Rockline" and others which are aimed at certain market segments. Satellite transmission offers the opportunity to reach widely dispersed small pockets of the population which have been underserved up to now.

In order to project the future demand for radio, the market is divided into five segments: Public Radio, Commercial Radio, Occasional Radio, CATV Music and Music Recording Channels. Each of these sections is discussed below and the baseline forecast for radio broadcast is then explained.

A.2.3.1 Public Radio

The National Public Radio (NPR) network pioneered satellite transmission of radio programming in 1978. Under current plans, NPR will become the largest single radio network in terms of number of channels and variety of programming, going from 8 channels in 1980 to 24 in 1983 [9]. NPR will include dramatic programming, specialized audience programming, educational programming and extended program service. The wide range of NPR programming is the product of a variety of listener demand and NPR's attempt to meet this demand.

A.2.3.2 Commercial and Religious Radio

The number of commercial radio networks has increased greatly over the last two decades, from four networks in 1960 to over twenty today. These networks

generally provide news and entertainment programming, although a few networks provide exclusively news or entertainment. Entertainment programming is predominantly music, with many networks airing live concerts. Available networks cover the entire range of today's music from top 40 to classical and pop to soul. There are also several religious broadcast networks, the PTL network being one example.

The first commercial network to use satellite transmission was RKO in 1979. RKO has two networks and will open their third network shortly. A review of satellite transponder usage reveals that approximately 13 channels of commercial radio traffic are currently being carried. Religious broadcasting is being carried on three channels.

A.2.3.3 Occasional Radio

Most regional or national use of radio programming comes from the broadcast of an occasional event. Religious broadcasts, sports, live concerts, simulcast of live TV and other events fall under this category. Occasional radio is interspersed with a station's regular programming whereas network radio becomes a station's regular programming.

A.2.3.4 CATV Music

Cable operators are finding it very popular to include a channel or two of music along with their regular video broadcast. This can be supplemented with concerts or interviews to be a full channel offering. New franchises are offering around 100 stations and will need something to fill the gap between available programming and the number of stations offered.

A.2.3.5 Recording Channel

A new service which could revolutionalize the music recording industry by 1990 is in its infancy. Digital Music Company has begun broadcasting two channels of very high quality music which may be recorded by making arrangements in advance. This is expected to provide a cheaper means of distribution, especially for recordings with low demand such as Mozart. Two audiences are expected to

be attracted to this offering: those living in areas where certain music is difficult to obtain and music buffs wanting the highest quality recording available. Digital music is expected to start with two channels this year, which would be scrambled to households that had not paid to tape the record.

A.2.3.5.1 Baseline

In order to determine the baseline forecast for radio broadcast applications, the five services were reviewed to determine their current and future demand. This demand is expressed in terms of channels (see Table A-10) required to carry the service. This process included:

1. Determining what channels were currently using satellite transmission.
2. Determining the announced plans for new channels over the next five years.
3. Projecting a growth rate based on the expected changes in each service and making a judgement as to how many channels will be required in 1990 and 2000.

Channels were then converted into transponders (see Table A-10) by considering such things as using SCPC transmission and transmitting to 3 meter antennas across the nation. In order to assure a high quality transmission, Western Union Engineering Group has estimated that 30 channels would be an appropriate number for a transponder under the above conditions.

In order to keep all voice transactions in half-voice circuits the number of transponders required was multiplied by the number of half-voice circuits per transponder in 1980, 1990, and 2000 as determined by Western Union engineers (see Table A-10).

A.2.4 Summary of Voice Baseline Forecast

The baseline forecasts for the specific voice services are presented individually and as a total in Table A-11. The corresponding growth rates are noted in Table A-12.

TABLE A-10
RADIO TRAFFIC FORECAST

	CHANNELS		
	1980	1990	2000
Public	8	30	33
Commercial and Religious	13	33	40
Occasional (weekend peak)	30	40	45
CATV Music	2	10	15
Recording	0	5	10
TOTAL	53	118	143

	TRANSPONDERS		
	1980	1990	2000
Public	.267	1.000	1.100
Commercial and Religious	.433	1.100	1.330
Occasional (weekend peak)	1.000	1.330	1.500
CATV Music	.067	.333	.0.500
Recording	0	.167	.333
TOTAL	1.777	3.930	4.763

	HALF VOICE CIRCUITS		
	1980	1990	2000
Public	320.4	1800.0	2640.0
Commercial and Religious	519.6	1980.0	3192.0
Occasional (weekend peak)	1200.0	2394.0	3600.0
CATV Music	80.4	599.4	1200.0
Recording	0	300.6	799.2
TOTAL	2120	7074	11431

TABLE A-11. VOICE BASELINE

(THOUSANDS OF HALF-VOICE CIRCUITS)

SERVICE	YEAR 1980	1990	2000
MTS (Residential)	593.0	1279.0	2639.0
MTS (Business)	1588.0	4118.0	8890.0
Private Line	644.4	2606.9	6761.7
Mobile	1.4	34.9	103.2
Public Radio	.3	1.8	2.6
Commercial & Religious	.5	2.0	3.2
Occasional	1.2	2.4	3.6
CATV	.1	.3	1.2
Recording	0	0	.8
TOTAL	2828.9	8045.3	18405.3

TABLE A-12. VOICE BASELINE - GROWTH RATES (ANNUAL, %)

SERVICE	TIME PERIOD 1980-1990	1990-2000
MTS (Residential)	8.0	7.5
MTS (Business)	10.0	8.0
Private Line	15.0	10.0
Mobile	37.9	11.5
Public Radio	19.6	3.7
Commercial and Religious	14.9	4.8
Occasional (Radio)	7.2	4.1
CATV Music	11.6	14.9
Recording (Radio)	0.0	0.0

A.3 DATA APPLICATIONS

There are several trends which indicate that the volume of data transmission will increase substantially in the coming years. The United States is moving toward a service/information oriented society. As this occurs, there is a need to increase the productivity of white collar workers. The harnessing of microchip technology with its favorable price to performance ratio has begun to answer this need. As computers become more commonplace in toys, automobiles, and banking, society is learning just how powerful and just how simple to operate a computer can be. This in turn is lowering the business community's natural resistance to change. Acceptance of computer technology combined with huge price drops have made the computer an invaluable tool at all levels and for all sizes of business. An explosion in the market for home computers for entertainment, finances, and information also is just around the corner. Complementing these trends is the merger of communications and data processing. The amount of information passed from computer-to-computer will grow tremendously as this takes place.

In order to develop a baseline forecast for data, seventeen services were defined. Some services shared common traits and were, therefore, grouped together for ease of forecasting. These services and groupings are indicated below:

Terminal Operations	Data Transfer
	Batch Processing
	Data Entry
	Remote Job Entry
	Inquiry Response
	Timesharing
Electronic Mail	USPS EMSS
	Mailbox Services
	Administrative Message Traffic
	Facsimile
	Communicating Word Processors

Record Services	TWX/Telex Mailgram/Telegram/Money Order
Other Terminal Services	Point of Sale Videotex/Teletext Telemonitoring Secure Voice

The first six services all deal with general purpose terminals and the transfer of data. Traffic projections primarily were based on the terminal population. Traffic projections for the three services under electronic mail depend to a great extent on the amount of traffic which is diverted from other forms such as first class mail or intercompany mail. The other two services under electronic mail are projected based on the number of machines in use, frequency of use, and the length of the average business transmission. Record services are handled largely by Western Union and projections are based on actual traffic figures and long-term trends. The four services under the other terminal services categories used identifiable terminals which were unique and are projected based largely on discussions with industry sources.

For the seventeen data services, all traffic is stated in terms of terabits (bits x 10^{12}). One bit of information is either a "1" or "0" and it usually takes 8 bits to represent a character such as an "a". Since bits are used by computers and any form of digital transmission, it is natural to state the traffic in this way.

A.3.1 Terminal Operations

The first six of the data services have been classified as terminal operations. The base for all of these services is derived based on the terminal population in the United States. This refers to general purpose terminals which are commonly used to input or receive information from a computer. It includes home computers but not point of sale transactions which require unique equipment.

A.3.1.1 Data Transfer

Data transfer is a process in which information is electronically transferred from one storage bank to another in a non-update fashion. The transfer usually takes place during the off-peak transmission time. This application is used by insurance companies, financial institutions, the banking industry, and the like. The transmission speed in bits per second (bps) will depend on the volume of data to be transferred. For large amounts of data, the speed is usually 56 kbps and up. Electronic fund transfer systems and point of sale systems could also make use of this application.

A.3.1.2 Batch Processing

Batch processing is a procedure that is volume rather than time oriented; it is prepared according to a schedule rather than on demand. Typical examples include daily sales orders, weekly payroll information, etc. Usually batch processing is implemented on transmission facilities with speeds higher than 56 kbps.

A.3.1.3 Data Entry

In data entry, the information is captured in complete readable format at its source and added to an existing data base, eliminating the intermediate keypunch mode. Equipment used in this application includes general purpose as well as application unique terminals. The facility speed depends on the volume of data and may vary anywhere from 2.4 kbps to 56 kbps or up. Typically, data entry can be utilized for electronic funds transfer systems such as those used by the banking industry and financial institutions and point of sale applications used by the retail industry.

A.3.1.4 Remote Job Entry

Remote Job Entry (RJE) is the process of remotely controlling the initiation and termination of computer processing related to a specific job or run. Essentially, this remote control capability affords an operator the same level of processing capability as if he were within the computer facility. It differs from data entry

in that RJE involves manipulation of the received data and transmission of the output to the originator after processing. This application will typically be used by universities or any organizations with dispersed locations. The speed of transmission ranges from 1.2 to 9.6 kbps.

A.3.1.5 Inquiry/Response

Inquiry/Response is characterized by its urgency and is usually transmitted in a real time manner through operator-entered inquiries to an existing data base which can then be manipulated and corrected. Common applications include airline reservation systems, stock exchange quotations, inventory status and account balances. The speed of transmission may vary from 1.2 to 9.6 kbps.

A.3.1.6 Timesharing

Timesharing is the shared use of centrally located computer facilities by several operating entities. The computer facilities can store, manipulate and transmit data simultaneously among the several users, generally on a real time basis. The supplier of the central computer facilities may be a commercial organization serving many unassociated users, known as commercial timesharing, or a private supplier serving in-house computing needs, referred to as private timesharing. The transmission speed will also vary from 1.2 to 9.6 kbps.

A.3.1.7 Baseline for Terminal Operations

To estimate the magnitude of terminal operations traffic, the following procedure was used.

a. Estimate the number of data entry terminals in 1980 and the projected growth pattern for the years 1990 and 2000.
b. Estimate the number of terminals being used for various services.
c. Estimate the average thruput of each terminal. This estimated thruput is a function of the following:
    1. Number of bits transmitted per character
    2. Average number of characters per second transmitted

3. Number of hours per year the terminal transmits.

The Market Research Department of Western Union has estimated the 1980 and expected future traffic of data communication. This information was published in the report by Western Union [10]. The Western Union Market Research Department has developed most of the data from a compilation of many existing market research reports, primarily those of International Data Corporation[11,12,13,14], Yankee Group[15], Future Systems Incorporated[16,17], Prodcasts[18] and Author D. Little[19]. In general, a consensus approach was used for conclusions presented in this document. However, on certain occasions, the opinions, and sometimes judgment, of Western Union's Market Research Department was given a relatively heavy weighting.

Western Union's report estimated the total installed base of terminals in 1980 to be 7 million increasing to 21 million by 1990, an annual compounded growth rate of 11.6%. That report estimated that 70% of a potential 30 million white collar users will be using terminals by 1990. The growth will be fastest in the earlier half of the decade and slow down during the later half as the saturation of the potential users takes place.

Furthermore, a summary of the findings published by the U.S. Department of Commerce[20] indicated an increase of 11.6% in the shipment of computers in 1980 over 1979. It is, therefore, Western Union's opinion that, barring any serious downturn in the U.S. economy, an 11.6% compounded growth rate in data communication is realistic and achievable.

Subsequent to the estimation of the computer terminal population, the next step was to estimate the data entry terminal equipment that communicates with other computer equipment in an internal or external network. In a research report published by International Data Corporation[12], the following results were obtained as a consequence of random sampling of terminal users:

> Based on 594 terminals in operation at various survey sites, 58% of the terminals in this industry grouping communicate with an in-house host computer. 11% of the total number of terminals communicate with a host computer at another location. 6% of the total operate

with a service bureau, which is followed by 3% communicating with externally located terminal equipment. A sizable group of 22% of the total terminals are used in an off-line mode.

As the next step to arrive at projections for data traffic demand, the average number of bits per year originated by each terminal engaged in communication with an outside computer was needed. The following statistics were obtained from a study conducted by the Yankee Group(21).

less than one hour	14.6%
one to two hours	18.1%
two to four hours	21.1%
four to six hours	16.1%
six to eight hours	29.8%

An average usage of four hours per day is derived from the following:

$$\text{Average Usage Time} = \frac{0.5 \times 14.6 + \frac{(1+2)}{2} \times 18.1 + \frac{(4+2)}{2} \times 21.1 + \frac{(4+6)}{2} \times 16.1 + \frac{(6+8)}{2} \times 29.8}{100}$$

$$= 3.87 \text{ hours} \doteq 4 \text{ hours}$$

Since no published statistics are available for the number of characters per second, a statistically "representative" terminal-to-computer transaction has to be determined. While many different transaction types may be postulated, an appropriately chosen representative transaction serves to define a data rate reasonably close to the average thruput at each terminal. A typical terminal-to-computer transaction is postulated as follows.

The transaction begins with a human input, assumed to be 80 characters long and limited in speed by the keyboard entry to about 5 characters per second. After a five-second response time, which allows for communications turn around and queuing and processing delays, the computer responds by painting the screen with 500 characters of data (one-fourth of a typical full screen). The elapsed time,

using 9600BPS line speed for this 500/960 transaction, is 0.5 seconds. Twenty-five seconds are then allocated for absorbing the information presented, and an additional five seconds is assumed to elapse before the operator begins the next transaction. A total of 51.5 seconds is required for the complete transaction, during which 580 characters are transmitted in one direction or the other. Thus, the average speed during the transaction is 580 divided by 51.5, or 11.2 characters per second. Assuming that the average terminal is in use 250 days per year and 4 hours per day, and assuming 10 bits per character to allow for communications overhead, the result is a communications load of 400 M bits per year (10 bits per character X 250 days X 4 hours per day X 3600 seconds per hour X 11.2 characters per second).

Since there are no available statistics on the number of terminals dedicated to various services, the number of terminals allocated to various services was estimated based on the opinions of Western Union's marketing department and relevant information derived from other published sources.

As noted above, it has been estimated that about 7 million terminals were in use in 1980. International Data Corporation's findings indicate that about 42% of the terminal population is engaged in communications with a distant host or central computer. It is estimated that about 25% (one million) of the remaining 58% (four million) are involved in terminal-to-computer transmissions. Since data transfer and data entry are volume oriented, the terminal allocation for data transfer and data entry is adjusted by 400,000 and 600,000 respectively. The average terminal usage time for data transfer and data entry has increased from four hours to six hours for year 2000. For the remaining services the usage time is maintained at four hours per day.

The communication traffic forecast for 1990 is based on 1980 traffic estimates. Western Union's market studies(10,22) indicated that by 1990, the terminal population will rise to 21 million, an annually compounded increase of 11.6%. Similarly to the 1980 estimate for data transfer and data entry terminals, the terminal population is enhanced by 1,210,000 and 1,830,000 terminals respectively. For the year 2000 estimates for data transfer and data entry terminals the population is enhanced by 3,610,000 and 5,490,000 respectively.

Proliferation of small business and personal computers will have a significant effect on communications requirements. A marketing report by Frost and Sullivan(23) predicts that nearly four million small business computers will be sold during the 1980s.

Although "home communications centers," increasingly popular due to the rapidly declining prices of personal computers, are not fully evaluated, they could have significant impact on communications requirements as more and more information services are furnished to potential users. It is estimated that in 1990 about 4 million home computers will be in use with a potential capture of 50% (2 million) of the market in communications activity. Assuming a 6% annual increase in home computers, 3.6 million will be used in communications by the year 2000. Therefore the population for data entry was augmented for these years.

For the year 2000, an estimated 11.6% annual increase in terminal population is expected for data transfer, data entry and inquiry/response, and 6.0% for batch processing, remote job entry and timesharing. The communications data traffic estimates for the year 2000 were based on emerging trends in the business world, technological advances and expected cost reductions in commmunications equipment. Some of the significant factors which will impact future data communications requirements can be envisioned as follows:

a. The entry of large financial institutions such as banks, insurance companies, brokerage firms, and large retail stores into "one stop" financial services.
b. Increasing proliferation of small computers for home information centers and small business establishments.
c. Aggressive growth fueled by technological changes and rapidly falling prices.
d. Specialized services that are beginning to be offered by new companies.

The allocation of terminals to various services for 1980 is as follows:

Data Transfer	26% of 2.94M	=	760K	+	400K	=	1,160K
Batch Processing	26% of 2.94M	=	760K				
Data Entry	12% of 2.94M	=	350K	+	600K	=	950K
Remote Job Entry	14% of 2.94M	=	412K				
Inquiry/Response	14% of 2.94M	=	412K				
Timesharing	8% of 2.94M	=	235K				

The number of terminals for the years 1990 and 2000 are calculated in accordance with the 1980 population as the base line. The terminal operations forecasts are presented in Table A-13.

A.3.2 Electronic Mail

Electronic mail is similar in many ways to regular first class mail. It is the handling of text by electronic means. The following services fall under electronic mail:

a. USPS EMSS
b. Mailbox
c. Administrative Message Traffic
d. Facsimile
e. Communicating Word Processor.

A.3.2.1 United States Post Office Electronic Mail Switching System

On January 4, 1982, the United States Postal Service (USPS) introduced Electronic Computer Oriented Mail (ECOM). ECOM users will transmit correspondence in digital form via telephone lines to a serving post office (SPO) in one of 25 major cities. The SPO then automatically prints the letters out on paper, folds them, inserts them into envelopes, and mails them first class within two days to their destination. ECOM users can also send their messages to Western Union Electronic Mail, Inc. (WUEMI) from any compatible communicating word processor, computer-generated tape, or facsimile terminal for conversion to ECOM format. WUEMI has on-line at least 43 types of terminals made by 33 manufacturers which interface with ECOM hardware.

TABLE A-13. SERVICE IDENTIFICATION FOR DATA TRANSMISSION

	Number of Terminals 1980 ($X10^3$)	Bits per Year per Terminal ($X10^6$)	Bits per Year 1980 ($X10^{12}$) C1 x C2	Number of Terminals 1990 ($X10^3$)	Bits per Year 1990 ($X10^{12}$) C2 x C4	Number of Terminals 2000 ($X10^3$)	Bits per Year per Terminal ($X10^6$)	Bits per Year 2000 ($X10^{12}$) C6 x C7
Data Transfer	1,160	400	464	3,500	1,400	10,400	600	6,240
Batch Processing	760	400	304	2,300	912	4,100	400	1,640
Data Entry	950	400	380	4,900	1,960	12,200	600	7,320
Remote Job Entry	412	400	165	3,200	1,295	5,800	400	2,320
Inquiry/Response	412	400	165	3,200	1,295	9,700	400	3,880
Timesharing	235	400	94	700	268	1,300	400	520
TOTAL	3,929		1,572	17,800	7,130	43,500		21,920

Note: Due to round-off some numbers may be slightly different

Presently, only bulk users are availing themselves of the service since a minimum of 200 messages must be sent per transmission. Businesses may send out bills, direct mail solicitations, or other large volume mailings. All popular computer communications interface, enabling users to establish a direct link between their computer systems and an ECOM computer located at an SPO or an indirect link through a public computer network.

Common carriers are opposed to ECOM's intervention into an already competitive market. They argue that the USPS may divert revenues from other classes of mail to support it. Since ECOM mail is eventually delivered first class, mail from the SPO's might take the same time to send from the user's home territory or across the country. Only if the SPO's were linked via communications channels would this method prove more efficient.

USPS will have fierce competition from other computer based message systems (CBMS) and local networks providing electronic mail service in the 1980s. It is estimated at least 60% of first class mail involved in business or government financial transactions could be diverted to pre-authorization; potentially, half USPS's revenue could be lost due to Electronic Funds Transfer (EFT). USPS costs are relatively fixed; if volumes decrease, revenue will suffer.

USPS must try other means to divert message traffic. It is estimated that the following 1980 traffic could be diverted:

SOURCE	BILLION MESSAGES PER YEAR
Electronic Public Message Services	0.89
Transactions and Data Entry Traffic	3.60
Batch and File Transfer Traffic	10.00
Potentially Diverted Mail	27.50
Substitutable Voice Telephone	1.74
Total	44.73

Hence, 44.73 billion messages per year could be diverted to ECOM services. If messages from these sources increased by an average of 4 billion per year until 1990, anticipated message traffic would be 84.73 billion messages per year.

If only 50% of this total were diverted to ECOM by 1990, a total of 338.4×10^{12} bits per year would be transmitted.

$$\frac{84.7 \text{ X } 10^9}{2} = 42.3 \text{ X } 10^9 \text{ messages per year}$$

$$42.3 \text{ X } 10^9 \text{ messages per year X 1,000 characters per message X 8 bits per character} = 338.4 \text{ X } 10^{12} \text{ bits per year}$$

If the amount of potentially diverted mail continued to grow by an average of 4 billion messages per year by the year 2000 message traffic transferred to ECOM and similar services would total approximately $996.8 \text{ X } 10^{12}$ bits per year. The USDS/EMSS Traffic Forecast is presented in Talbe A-14.

A.3.2.2 Mailbox

A computer mailbox system is related to computer message switching in the same relationship that a postal service box is related to home delivery. In message switching, the computer delivers the mesage to a terminal or notifies the terminal of a message that is waiting. In computer mailbox, the user must check the box, which is in some preassigned location in the computer's memory, typically a disk file.

Mailbox service evolved within the scientific and academic communities among users who all shared the same computer network for timesharing purposes. Mailboxes are set up to allow store-and-forward message switching. It is a very useful service when the user travels and uses the network frequently. In an environment where many users share only a few terminals, message switching rather than mailbox service should be used.

Presently, mailbox and message switching systems are often separate, with mailbox systems unable to deliver messages. In the future, these two will probably be merged so that a user can either call in as if the system had a mailbox or have the message delivered automatically when the assigned terminal registers that it is available for delivery.

TABLE A-14. USPS/EMSS TRAFFIC FORECAST
(terabits)

YEAR		
1980	1990	2000
0	338.4	996.8

Leading providers of electronic mailbox systems include: Dialcom, Computer Corporation of America (Comet), General Electric Information Services (QUIK-COMM), I. P. Sharp, CompuServ, and Source Telecomputing. Together they share an estimated $25 million market for 1982.

The entry of AT&T's Advanced Information Service (AIS) packet switching network into this market will greatly accelerate the growth of message services with accent on mailboxes as increased postal rates continue to exceed the cost of electronic mail. AIS will capture a much broader market than the other packet services, including a home market and a substantial small and medium-sized business market. By the year 1992 the electronic mailbox and store-and-forward message switching market could amount to as much as $500 million, with AT&T in control of $350 million. Other vendors expected to enter this market include ITT, RCA, Federal Express, and MCI (which is acquiring WUI).

Dialcom claims to have 12,000 mailboxes (giving one to each of its timeshare customers). Tymnet's "OnTyme" has 2,500 to 3,000 mailboxes. Every electronic mail system uses Telenet, Tymnet or direct dial to send messages. For example, Comet has access to Tymnet and Telenet and had 2,000 subscriber mailboxes on its network (representing 60 companies) and had sold 11 private systems (approximately 3,500 mailboxes) by August 1980.

The mailbox traffic forecasts are presented in Table A-15. To determine the number of bits per year the following assumptions were made:

a. Two to three messages per day per user
b. Each mailbox has one user
c. Each message contains approximately 1,000 characters with 8 bits per character
d. Twenty-two working days per month.

On the basis of these assumptions it was estimated that there were .32 terabits per year of mailbox traffic in 1981. Assuming a 50% growth rate between 1980 and 1981, the 1980 traffic amount was calculated to be $.213 \times 10^{12}$ bits per year. About a 35% growth rate was assumed for the period 1980-1990 and a 10%

TABLE A-15. MAILBOX TRAFFIC FORECAST

NUMBER OF BITS PER YEAR - 1981

	Number of Mailboxes	Percent	Number of Messages Per Year	Number of Bits Per Year
QUIK-COMM (GE)	20,000	41	15.8M	0.12×10^{12}
DIALCOM	12,000	25	9.5M	0.08×10^{12}
TELEMAIL (by Telenet)	8,000	16	6.3M	0.05×10^{12}
COMET (CCA)	3,000	6	2.4M	0.02×10^{12}
INFOPLEX	3,000	6	2.4M	0.02×10^{12}
ON-TYME II (Tymet P/O Tymeshare)	3,000	6	2.4M	0.02×10^{12}
TOTAL	49,000	100	38.8M	0.31×10^{12} (0.31 terabits per year in 1981)

NUMBER OF TERABITS PER YEAR

1980	1990	2000
0.213	4.9	12.7

growth rate for the period 1990-2000. The resulting 1990 and 2000 forecasts are presented with the 1980 forecast in Table A-15.

A.3.2.3 Administrative Message Traffic

Administrative messages are usually short (approximately 1,000 characters) person-to-person messages. Examples include travel information, new product announcements, performance reports, and non-record keeping tasks.

Administrative messages differ from data communication messages in that data communications are usually in numeric form. Some examples are data base entry, inquiry/response, remote job entry or batch processing data. Much of this traffic (approximately 25 billion intracompany messages) is still delivered manually through company mail rooms. However, there is a rapidly rising trend to transmit administrative messages via computer base message switching (CBMS) systems and communicating word processors (CWP). Companies may select from a variety of CBMS suppliers ranging from value-added carriers and vendors of public message services to software houses and manufacturers of larger mainframe computers and automated office equipment. A number of vendors, among them Telenet and Tymnet (non-military) and ARPANET and AUTODIN (military), provide external packet switching networks linking their users. AT&T's recently introduced Advanced Information System (AIS) will provide a packet network with a broad range of messaging capabilities. With the advent of office automation, many companies are purchasing their own private local networks providing high speed, short haul multi-dropped party line links to which a variety of electronic equipment may be attached.

A.3.2.3.1 Baseline

Administrative message traffic will be routed through CBMS systems and packet switching networks. Message traffic volumes for both government and non-government use will encompass all of these. In 1980, 50 million messages were delivered through CBMS while 95 million messages went via packet switching networks.

Among those agencies studied were the Federal Reserve Bank, the Veterans Administration, the Federal Bureau of Investigation, the Department of Justice, the Department of the Interior, and the Department of Agriculture as well as many smaller governmental entities. A breakdown of the approximate number of leased circuits at each baud rate is shown below:

(A) SPEED (BPS)	(B) NUMBER OF CIRCUITS	(A) X (B) (KBPS)	TOTAL MBPS IN THE PEAK HOUR
300	208	62.4	224.6
2400	1,580	3,792.0	13,651.2
4800	630	3,024.0	10,886.4
7200	6	43.2	155.5
9600	544	5,222.4	18,800.6
56K	79	4,424.0	15,926.9
250K	8	2,000.0	7,200.0
1.5M	6	9,000.0	32,400.0
		27,568.0	99,244.7

Rounding off the total of 99,244.7 Mbps in the peak hour to 1×10^5 Mbps, a conservative estimate is that peak hour traffic is half the daily traffic in a 22 day month. Thus, the annual total of bits transferred is 52.8 trillion bits.

If we include Western Union's Advanced Record System (ARS) with its 0.6 trillion bits of traffic per year we get a total of 53.4 trillion bits per year in non-military message traffic.

Military traffic is handled commercially by two major switching systems, AUTODIN and ARPANET.

AUTODIN I	10.0	trillion bits per year
ARPANET	3.1	trillion bits per year
TOTAL	15.1	trillion bits per year.

The combined military and non-military traffic flow follows:

Non-military	53.4	trillion bits per year
Military	15.1	trillion bits per year
Total	68.5	trillion bits per year

Assuming that 25% of this traffic may be considered administrative, government message traffic in 1982 totaled 17.1 trillion bits per year.

Using a growth rate of 12% for the last few years, we arrive at a 1980 baseline figure for government administrative message traffic of 15.3 trillion bits per year.

There are approximately 3,500,000 non-government terminals which presently engage in data transfer, batch processing, data entry, remote job entry, inquiry/response and timeshare in mid-1982.

a. Assuming 25% of these are used for administrative message traffic, then:
   3.5×10^6 terminals $\times .25 = 0.88$M terminals are used for administrative traffic

b. If each terminal transmits approximately 20 messages per day, the daily administrative message traffic is:
   $.88 \times 10^6 \times 20 = 17.6 \times 10^6$ messages per day

c. Assuming a 22 day working month:
   17.6×10^6 messages per day X 22 days per month X 12 months per year $= 4.6 \times 10^9$ messages per year

d. Average message is approximately 1,000 characters and consists of 8 bits per character:
   4.6×10^9 messages per year X 1,000 characters per message X 8 bits per character $= 37.2 \times 10^{12}$ bits per year (mid-1981 to mid-1982).

Assuming we've had a 12% growth rate per year extrapolating back to 1980 equals:

$$\frac{37.2 \times 10^{12} \text{ bits per year}}{1.12} = 33.2 \times 10^{12} \text{ bits per year in 1980 to 1981}$$

The baseline forecast for total government and non-government administrative message traffic in 1980 is 48.5 trillion bits per year.

Government	15.3	trillion bits per year
Non-government	33.2	trillion bits per year
Total	48.5	trillion bits per year

The administrative message traffic for 1980, 1990 and 2000 are presented in Table A-16. The 1990 and 2000 forecasts are based on the following assumptions:

a. In 1990 demand will equal about 600% at 1980 demand (i.e. average annual growth rate = about 20%).

b. In 2000 demand will equal about 300% of 1990 demand (i.e. average annual growth rate = about 12%).

A.3.2.4 Facsimile

Three of the projected services are considered facsimile. The services are:

a. Convenience Facsimile (CITT Classes 3 and 4)

b. Operational Facsimile (CITT Classes 1 and 2)

c. Special Purpose Facsimile

Each of these services is discussed below, along with their current and expected demand. These forecasts are based on the type and number of machines in place, and an industry estimate of the number of pages transmitted during 1980.

A number of factors will cause this market to increase in the coming decades. The setting of standards by the Consultive Committee for International Telephone and Telegraph (CITT) will encourage international as well as inter-company transmission. The trend among business and government users is toward higher speed machines. These machines will be digital with rates as high as a second per page. Satellite Business Systems (SBS) has already demonstrated

TABLE A-16

ADMINISTRATIVE MESSAGE TRAFFIC FORECASTS

(TERABITS/YR.)

YEAR		
1980	1990	2000
48.5	300	933

this capability through their satellites. As a result, it appears the market for the slower machines (Classes 3 and 4) will decline after 1985.

A substantial market is expected to develop in the private sector, however. Both France and Japan predict a low cost facsimile machine in the near future. Three French companies are currently planning to enter the fax market in the U.S. Their equipment is expected to penetrate the low volume, small business user. In addition, Japan has predicted a market for facsimile machines priced as low as $100 for home use by 1985.

A.3.2.4.1 Baseline

The approach used to project the facsimile markets was as follows:

a. Determine the current and forecasted market for each category of facsimile equipment.
b. Determine the usage associated with each category of equipment.
c. Analyze usage trends for each application.
d. Quantify usage in bits per year.
e. Calculate market demand for 1980, 1990 and 2000.

Convenience Facsimile is defined as the slow to medium speed (2 to 6 minutes per page) machines. Our last report gave an estimate of 167,000 such machines in 1978. A review of market statistics of the machines shipped in this range reveals that in 1980 approximately 210,000 machines were in place. The number of pages sent in 1980 is estimated at 214 million, or 102 pages per month per machine. According to industry estimates the growth rate for slow facsimile is expected to remain high, at around 25%, through the middle of this decade. This growth is, however, expected to decline toward the end of the decade and remain around 10% during the 1990s largely due to two factors:

a. Industry will demand higher speed facsimile.
b. The merging of facsimile with communicating word processors is expected to occur within the 1985 time frame.

Using a typical analog machine in place, it is possible to estimate the total number of bits transmitted per year. A machine which scans 100 x 100 points per inch will transmit 935,000 bits per page. At 4800 bps, a page takes three minutes to transmit. This times the estimated number of pages gives a yearly transmission of 200 terabits (bits x 10^{12}).

<u>Operational Facsimile</u> includes medium speed, high speed and wideband facsimile equipment. This equipment operates with a range of one second per page to two minutes per page. Growth in this service seems bright, at least up to 1990, with an expected growth rate of 20 to 35%. Medium speed machines (CITT Class 3) numbered approximately 17,000 in 1980, high speed machines 2,000.

Wideband facsimile machines came into use over SBS satellites in late 1981. Approximately 50 are now in use. Volume of pages transmitted was 200 per day for medium speed machines and 250 for the high speed and wideband machines. It seems unlikely that transmission volume will rise much for the medium speed machines while for the other two it should double by 1990 before leveling off.

For a medium speed machine with a typical 8½ by 11-inch page and a resolution of 100 x 100 lines per inch, there are 935,000 bits of information transmitted. Compression ratios vary from 2:1 to 100:1; in this case, a ratio of 6:1 was used. This gives an actual transmission of 156,000 bits, which at 2400 bps is transmitted in 66 seconds. Similar methods were used for high speed and wideband equipment. The total traffic generated in 1980 by Operational Facsimile was 11.3 terabits (bits x 10^{12}).

<u>Special Purpose Facsimile</u> is the type used by the police for fingerprints or by the weather bureau for maps, and therefore must be very high quality. Industry sources indicate 14,000 machines in operation in 1980 as opposed to 10,000 shown in our 1978 study, giving a growth rate of 18%. A slightly slower growth rate (15%) is indicated through 1990 with a decline (10%) after that due to other technologies. Using a typical machine of 9600 bps with a transmission time of three minutes and no compression (because of the high resolution required) results in 1.73 million bits per page. With an annual usage of 14 million equivalent pages, yearly transmission is 24.2 terabits (bits x 10^{12}).

A review of facsimile user surveys reveals that the current trend is toward higher speed terminals. In addition, many users expect to change from analog to digital equipment. The most important feature of facsimile equipment is its ability to operate unattended. Many users operate across time zones or internationally and need a self-sufficient device. The amount of facsimile use between organizations is on the rise, along with the amount of standardization. One user survey reported a split of 77 to 23% between intra- and inter-organizational traffic.

Bankers Trust New York Corporation, the eighth largest bank in the United States, just started using facsimile in their financial operations. They deal with a number of large users, some with as many as 400 transactions per day. Hexcal, a high technology company in structural components for military aircraft, uses facsimile to send complicated chemical formulas and diagrams, as well as administrative messages. They estimate their headquarters alone sends 700 documents a month. Gulf Oil has just installed a digital system of facsimile distribution with an estimated savings of $256,000 per year. As more and more companies enhance their communications capabilities, facsimile use will continue to grow.

A summary of the facsimile traffic forecasts is presented in Table A-17.

A.3.2.5 Communicating Word Processor

A communicating word processor (CWP) adds communication capability to a printer/keyboard or CRT-based word processing system. This allows the input to be prepared on one system and sent via communication links, at a speed ranging from 1.2 to 9.6 kbps, to another system for output, editing or manipulation. The advantage to the user is the ability to transmit "original" quality documents with format control similar to letter and memo correspondence.

The market for CWPs is expected to enjoy rapid growth in the next decade and to continue to the year 2000. With the addition of such networks as AT&T's Advanced Communication Service (ACS) and other packet networks, the CWP will become the single most important hard-copy device in interoffice communications.

TABLE A-17. FACSIMILE TRAFFIC FORECAST
(terabits)

	YEAR		
	1980	1990	2000
Convenience	200.0	382.3	775.9
Operational	11.3	76.3	211.4
Special Purpose	24.2	85.1	242.7
TOTAL	235.5	543.7	1230.0

A.3.2.5.1 Baseline

In forecasting the amount of traffic generated for each time period, the following steps were taken:

a. Determine the current and projected number of machines in operation.
b. Determine the usage time associated with each machine.
c. Estimate an average speed for each machine used.
d. Calculate the amount of traffic for 1980, 1990 and 2000.

The first Western Union report(1) estimated there were 79,000 CWPs sold in the U.S. in 1980. Industry estimates support this figure. User surveys indicate that the machines were in use on the average of five hours per day. Internal Western Union studies show that actual transmission occurs about 1% of this time in use, or 180 seconds per day. This estimate accounts for those machines not utilizing the communicating capacity as well as those making heavy use of that feature.

Multiplying this number by 250 working days in a year gives a total of 45,000 seconds per year that a CWP is transmitting. With an average machine speed of 4800 bps, this amounts to an annual transmission of 17.1 terabits.

Increased demand for the CWP can be expected to continue over the next decade. Several factors will contribute to this growth, one of which is the increased application of the CWP. For example, as multi-function workstations become more prevalent, office workers will enjoy the ability to send interoffice memos while sitting at their desks. Cost will be another important factor affecting growth. Previous reports showed that the cost of a CWP will decrease to $7,000 by 1984, less than half its cost in 1978. This downward cost trend is expected to continue well into the 1990s, but at a more gradual rate. As the cost of the CWP decreases, this technology will become available to a larger market segment. Finally, the setting of standards for CWP communications will allow different manufacturers' machines to communicate, increasing the flow of information between systems and individuals.

In 1990, the number of CWPs forecast will be 270,000. A modest increase in usage time is expected, increasing the transmitting time per machine per year to 90,000 seconds. (This was held constant in 2000.) Multiplying the number of machines by the usage time and then figuring an average speed of 4.8KBPS produces a transmission demand of 117.1 terabits in 1990.

The usefulness of the communicating word processor will be further enhanced by the availability of public networks supporting its use. This will continue into the 1990s, as will the merging of CWPs with facsimile. Costs are also expected to continue their gradual decline during this decade. Considering the 923,000 communicating machines that are forecast and their average speed of 4.8KBPS, the demand in the year 2000 is projected at 400.3 terabits.

A summary of the CWP traffic forecast is presented in Table A-18.

A.3.3 Record Services

Two of the services being studied, TWX/Telex and mailgram, are record services. The current and projected demand for these services has been the subject of a number of internal Western Union studies. These studies are the basis for the information presented in this section.

A.3.3.1 TWX and Telex

TWX was formed by AT&T in the mid-1930s and Telex was formed by Western Union. Western Union acquired TWX from AT&T in 1971 and has controlled this service since then. Basically, the TWX/Telex service is a switched teletypewriter service operating much as the telephone system does. It is a slow means of communicating, with an operating speed of 45 to 150 bps for TWX and 50 bps for telex. Because of these slow speeds, the network is expected to simply maintain, if not lose, its customer base over the next two decades. Western Union, in an attempt to keep its customers, has introduced new features such as store-and-forward and broadcast services.

TABLE A-18. CWP TRAFFIC FORECAST
(terabits)

YEAR		
1980	1990	2000
17.1	117.1	400.3

A.3.3.1.1 Baseline

In 1980, the installed base of TWX/Telex terminals was 130,000, with almost all these terminals used by business, government or institutions. The estimated number of messages transmitted during 1980 was 150 million. An annual growth rate of 3% is expected during the 1980s and the 1990s. The average message is around 1,000 characters in length, or 8,000 bits, allowing for spaces. This figure times the annual number of messages produces a yearly transmission rate during 1980 of 1.2 terabits (bits x 10^{12}). Using this baseline figure and the expected growth rate, it was possible to predict the message numbers and transmission volumes; these are presented in Table A-19.

A.3.3.2 Mailgram/Telegram/Money Order

Mailgram, telegrams and money orders are all handled by Western Union and are all undergoing changes in response to customer needs. Mailgram message volume has grown steadily since Western Union introduced the electronic mail service in 1970. It combines the speed of Western Union's electronic switching and transmissions facilities with the economy of the U. S. Postal Service's local delivery capability for delivery the next business day anywhere in the U. S. and Canada. Through Western Union's Central Telephone Bureaus or public offices, telex subscribers can transmit mailgram messages directly from their terminals. Also, large volumes of mailgram messages prepared on computer tapes can be transmitted to the company's computer centers from designated offices or customer locations.

A new service known as "Stored Mailgram" is provided by a subsidiary, Western Union Electronic Mail, Inc. (WUEMI). It has grown substantially in the last five years, providing computer storage of frequently used mailgram message texts and address lists which can be accessed by a growing number of communicating word processors in the customer's offices. WUEMI also provides "Computer Letter" to commercial customers who do not need next day delivery. Messages are sent to WUEMI where they are processed and deposited with USPS as first class mail. Mailgram is also interfaced to Western Union's InfoMasters computer store-and-forward system.

TABLE A-19. TWX AND TELEX TRAFFIC FORECAST

	YEAR		
	1980	1990	2000
Terminals (thousands)	130.0	174.7	234.8
Messages (millions)	150.0	201.6	270.9
Transmission (terabits)	1.2	1.6	2.2

One of the oldest forms of electronic communication, the telegram, is still used for urgent messages or to make an impact. In the U.S. it is handled exclusively by Western Union and the forecast is based on internal information.

The money order, which is a way of electronically transmitting funds, handles small payments and thus is different from electronic funds transfer. Money orders are also handled by Western Union as well as by other companies.

The information for the market size and number of bits transferred comes from internal analysis. The actual calculation of traffic may be understood by the following tables. Tables A and C are used to derive Table D. Then using the number of bits per message (Table E) it was possible to determine the amount of traffic (Table A-20).

A. COMPARISON OF MESSAGE VOLUME

(millions)

	1977	1978	1979	1980	1981
Mailgram	28.4	32.7	37.4	39.0	40.9
Telegram (Domestic)	6.9	7.0	6.6	6.1	5.3
Money Orders	6.3	7.0	7.7	7.9	8.1

B. COMPARISON OF REVENUE

(dollars)

	1979	1980	1981
Mailgram	78,310	92,824	106,927
Telegram	67,154	64,433	71,008
Money Orders	60,940	70,407	80,718

C. GROWTH RATE

(percent)

	1980-1990	1990-2000
Mailgram	8	5
Telegram	-5	0
Money Orders	12	8

D. MESSAGE VOLUME

	(millions)		
	1980	1990	2000
Mailgram	39.0	84.2	137.1
Telegram	7.9	3.7	3.7
Money Orders	6.1	24.5	52.2

E. BITS TRANSMITTED PER MESSAGE

Mailgram	8000
Telegram	8000
Money Orders	2500

A.3.4 Other Terminal Services

Three of the services projected use special purpose terminals and fall outside the other categories. They are:

a Point of Sale
b Videotex/Teletext
o Telemonitoring
o Secure Voice

The forecasts for the first two services were done by contacting various industry sources where they would be used. Videotex/Teletext was forecast based on vendor interviews and anticipated machine use.

A.3.41 Point of Sale

A major amount of human drudgery will be saved when payments made by consumers in stores and restaurants are entered directly into the banking system instead of being made by credit card or check. Bank cards are the means of implementing such transactions.

"Point of Sales" (POS) terminals are used for sales transactions, credit authorization and some inquiry functions. Data entry may be made by a magnetic or

TABLE A-20
MAILGRAM/TELEGRAM/MONEY ORDER FORECASTS
(terabits)

	YEAR		
	1980	1990	2000
Mailgram	.31	.67	1.10
Telegram	.06	.03	.03
Money Orders	.02	.06	.13
TOTAL	.39	.76	1.26

optical wand passed over a label which reads and identifies the item, or through entry on a numeric and function key keyboard. Instructions to the operator and data being entered are displayed; data provided in response to an inquiry may be printed.

Cash transactions are handled solely by the interactions of a terminal and a programmed cluster controller located in each store. The programmed controllers operate automonously. Credit and check-cashing authorization, on the other hand, involve a check against a master file at a central computer location. Once a day, another central computer application draws data from all of the connected controllers so as to establish register balances and conduct an overall sales audit.

Another application of point of sale terminals concerns regulation of inventory flow. This application relies on separate display terminals in each store. Order entry is the function which creates purchase orders and inputs them into the purchase order data base. The receiving application verifies quantity and type of merchandise. Invoice data is then entered into the data base as accounts payable, and the cost calculated in terms of retail sales dollars. These functions are executed partly in the controller and partly in the central processor. The interaction is between each display terminal and the central computer via the same controller that handles the sales transactions.

For example, imagine a chain of stores located in several states. In this installation, a group of 20 department stores is being brought on-line, with one programmed controller in each store and a central computer to coordinate them all.

Point of sale terminals are connected to the store's programmed controller via a 2400 or 9600 bps transmission loop. The controllers, in turn, are each connected to the central computer by a separate 4800 bps telephone line. Each programmed controller manages from 60 to 120 point of sale terminals plus a display terminal and a printer. These terminals may handle from 20 to 30 transactions per hour, while the programmed controller in any one store may handle 2000 to 3000 transactions per hour during a peak sales period. Response

time at a POS terminal averages less than a second with fewer than 10% of the responses taking no more than 1.5 seconds.

Each credit authorization requires one or possibly two messages to the central computer. Inventory flow applications may involve as many as 4 or 5 messages per transaction to the central computer. The central computer then must be capable of handling 8 to 10 messages per second during peak sales periods, even though all cash transactions are handled locally using the in-store programmed cluster controller.

When the day's transactions are batched from all the store controllers to the central computer, the transmission must take place within a relatively short time, say 0.5 to 1.5 hours. The central computer must be capable of handling the equivalent of 10 to 20 messages per second for that period of time to transmit the records of tens of thousands of transactions in this mode.

Point of sale terminals are not necessarily communication-oriented devices. Many companies tend to use them in the closed environment of a store without linking them to a network. If they are used locally, then the computer also has to be on-site and that is not practical for a large company with dozens or even hundreds of retail outlets. Rapidly falling computer costs, especially for special purpose microprocessors and less expensive communication facilities, are making it more attractive to link POS terminals to a central site that can handle all of a company's outlets.

Integrated POS systems become cost effective only when a complete merchandise control system is implemented to take advantage of computer data entry as well as sales transactions. Not every retailer needs or can afford such a system.

It is difficult to estimate the number of POS terminals in the marketplace since definitions differ greatly. One 1977 report indicated that there were 151,000 POS terminals in 1977 growing to 590,000 in 1980. This is misleading. One must distinguish between a simple credit authorization terminal (CAT) with limited capability and a true point of sales terminal which can generate inventory information and handle direct debit transactions as well. In 1982, there exist only between 80,000 and 100,000 true POS terminals. As this number grows and

retail chains replace their simpler POS terminals with more sophisticated ones, much more inventory information will be entered and many more direct debit transactions will be made.

The vast majority of POS transactions are handled by credit cards. There are numerous types of cards available. Cards are supplied by commercial banks (VISA and MasterCard), by retail chains (Sears, Pennys and Montgomery Ward), by travel and entertainment concerns (American Express, Diners Club, Carte Blanche) and by the oil companies (Gulf, Texaco, Shell, Mobil, Sunoco and Exxon). Many other concerns also issue credit cards (Hertz, Avis, and National Car Rental) but these are mostly corporate and are on a much smaller scale.

Banks are beginning to issue their own cards which are both debit cards (with immediate withdrawal of funds at time of purchase) and credit cards. Still in their embryonic stage, these cards are replacing a number of regular credit cards and will be used on POS terminals.

A.3.4.1.1 Baseline

Assuming that credit card transactions will grow at an annual rate of 3%, the 50 billion transactions in 1980 will increase to 67 billion in 1990 and 90 billion in 2000. Presently, only 6% of these transactions are handled electronically, most of them primarily for credit card authorization. Each transaction involves on average four messages (two inquiries and two responses). Very little transfer of inventory information or direct debit transactions are performed (an estimated 1000 bits per transaction). As true point of sales terminals (electronic cash registers) become more widespread the percentage of transactions handled electronically will increase sharply with higher volumes of inventory and direct debit transfers being made. By 1990 80% of these transactions should be accomplished electronically. By the year 2000, it is estimated that almost all credit card transactions will be handled in this manner. Table A-21 reflects this phenomenon. The total number of bits estimated for POS terminals in 1980 is 12 trillion, 214.4 trillion in 1990, and 360 trillion in 2000.

TABLE A-21. POINT OF SALE TRAFFIC FORECAST

	YEAR		
	1980	1990	2000
Credit card transactions at 3% growth rate per year (billions)	50.0	67.0	90.0
Percent of transactions sent electronically	6.0	80.0	100.0
Transactions per year sent electronically (billions)	3.0	53.6	90.0
Messages per year at 4 messages per transaction (billions)	12.0	214.4	360.0
Bits per year at 1000 bits per message (terabits)	12.0	214.4	360.0

A.3.4.2 Videotex/Teletext

Electronic text systems are still in their infancy, yet common requirements and distinguishing characteristics of such systems have already been identified. This attempt to define electronic text systems has helped reduce some of the confusion caused by the proliferation of generic terms and brand names used to describe electronic text systems.

All electronic text systems, regardless of their individual names or technical features, display textual information on a video display screen. All of these systems require at least two components: a computerized data base to store information and a transmission system that links the data base to the people who want information from it. The data base can contain words, numbers, or graphic illustrations, while the transmission system can range from a common telephone line to a satellite. These systems are being developed and are intended to be used primarily by the consumer in his home or business.

Two of the major factors which distinguish one system from another, from the customer's point of view, are the amount of information that can be retrieved easily from the data base and the ability to add information to the data base. Some systems are like a telephone, in that they have a two-way capacity which allows them to function as electronic mailboxes or bulletin boards. Customers can use them to bank, shop, send a letter to a friend or advertise the sale of a used car. Other systems are more like a cross between a book and TV: they are strictly one-way and the customer can receive information from the data base, but cannot transmit or add information to the data base.

Videotex is a synonym for electronic text and an umbrella term that includes teletext and Viewdata. Teletext refers to an electronic text system that usually relies on broadcast frequencies to transmit information. Like television itself, teletext systems could use a full broadcast channel; but since spectrum space is scarce, most teletext systems rely on what is called the vertical blanking interval, an otherwise unused portion of the television signal, or they rely on a single cable channel. Teletext flashes "pages" of text, one after another, in a cycle that is repeated continuously. The user punches a code into his modified TV set and the requested information is pulled out the next time it is

transmitted. The teletext data base is updated frequently and includes news, sports, weather and the like.

Viewdata systems offer customers access to a library of information and allows them to dial up information such as a sports score, restaurant review or airline schedule. Because viewdata uses a technical design different from teletext, its customers can retrieve information more quickly and from a much larger data base. Also, it is not limited to broadcast or one-channel transmission; it can operate via telephone lines or two-way cable systems. This interactive feature makes possible services like home banking, tele-shopping and advertising.

The basic teletext system works as follows:

a. The information, consisting of alphanumeric or graphic images, is encoded in a bit stream of digital data at a transmission rate that the television system can properly handle.
b. The encoded digital data is inserted or multiplexed onto the TV signal in such a way that it is located on unused lines in the vertical blanking interval.
c. The teletext signal can be detected by a special decoder that is either a separate accessory to the TV receiver or is actually built into it. In either case, the teletext decoder circuitry can accept the digital data, store one or more pages in a buffer memory, and display these pages on the screen as directed.
d. When the viewer punches the number of the desired page on his control keypad, the buffer memory containing that page is kept in a "hold" condition. The page is then transferred to the TV screen via a character and graphic generator which is part of the teletext decoder circuitry. The page remains on the screen until a replacement page is transmitted, or until the viewer selects a new page.

The essential elements of a viewdata service are:

a. A large computer that can store many thousands (perhaps even millions) of pages of textual information.

b. Computer programming (software) that permits the accessing and rapid retrieval of specific items of that information.

c. Transmission lines for sending information back and forth between the customer and the computer. These lines can consist of the public telephone network, a cable television system with two-way capabilities, or special microwave facilities.

d. Display and retrieval terminals. These can be TV receivers, with decoders attached to translate digital signals into the TV display, or modified computer terminals. As with the teletext decoder, a microprocessor that can be manufactured in large quantities is essential to a reasonable price. When used with phone lines, the terminal must contain a modem that converts an analog telephone signal into digital form for display. The retrieval device may be a simple calculator-like keypad with buttons for numbers 1 through 10, or a full typewriter-like unit.

A.3.4.2.1 Baseline

Videotex systems are still at the level of technical and market trials in the United States. The basic technologies are still evolving, so potential applications are still taking shape. Consequently, the volume of traffic consists primarily of traffic generated in market trials and a few commercial offerings.

The major contenders for the videotex market who are already conducting tests include the service providers, system operators, transmitters, and home terminal manufacturers. From 1980 to 1981 some 30 application trials of teletext and videotex were conducted in the United States. Even though there are no profits as yet, and sales are still miniscule, a wide variety of U.S. companies are already investing nearly $100 million in developing and testing videotex systems. On a worldwide basis, it has been estimated that some eighty-three experiments are now going on, with the total investment amounting to a quarter of a billion dollars.

The number of users, the amount of usage per week, and the time of usage will differ for business and home users. The ratio of business to home users is

estimated at 2:1 for 1982, 1:1 by 1990 and 1:2 by year 2000. Average business usage per week will start very low (at about 10 minutes per week) and will grow to 5 or 6 hours per week. Home usage will also start low (at about 10 minutes per week) and will grow to 1 or 2 hours per week. Considering times of usage, it was estimated that about 75% of the total usage (business plus home) will occur from 9 a.m. to noon and 1 p.m. to 5 p.m.; the peak time will occur at about 2 p.m.

The total users (home and business) presently involved in a videotex testing system or receiving commercial service number about 75,000. An estimate of traffic is based on the following assumptions:

a. 75,000 users.
b. 10 minutes of use per week per user for 52 weeks of the year.
c. 2 pages per minute.
d. 700 characters per page.
e. 8 bits per character = 5.424×10^6 bits.

Total estimated traffic is .44 terabits per year. About 10%, or .044 terabits, is estimated to be long haul (more than 100 miles) traffic.

The future volume of traffic generated by videotex systems is difficult to forecast for the following reasons:

a. The technologies supporting videotex systems are still undergoing significant changes.
b. The videotex product is still not well defined; which applications will be included is not clear.
c. There are many unanswered questions relating to spectrum allocation, standards, licensing and regulation.
d. The roles of the various providers are not well defined.
e. It is uncertain how quickly consumers will accept videotex as a way of communicating.
f. It is unclear how much consumers will be willing to pay.
g. Which applications will provide the driving force for the spread of videotex is unclear.

h. It is difficult to estimate how videotex will compete for time and money with other electronic products.

However, there are several events and trends which suggest that the videotex market could become quite large. A wide variety of United States companies are already investing heavily in developing and testing videotex systems. Telephone companies, broadcasters, cable TV operators, publishers, retailers, banks, and equipment manufacturers all are increasing their videotex efforts.

AT&T has endorsed videotex, telling its competitors and customers that it would design its own system, while more and more two-way cable TV systems are being built.

United States businessmen have been spending at an accelerating rate over the past decade to obtain electronically stored information. The general public is also becoming more receptive to electronic systems and therefore more willing to pay for transaction processing and financial services.

Based on interviews with providers and on a wide variety of articles and reports discussing videotex sytems, the total volume of future traffic generated by these systems is expected to increase from the current .44 terabits per year to 1,835 terabits in 1990 and 6,115 terabits in 2000. It is expected that about 10% of the traffic will be long haul: 184 terabits in 1990 and 612 terabits in 2000 (see Table A-22).

These growth rates are based on the following assumptions:

a. Estimated users: 15 million ir 1990; 50 million in 2000.
b. Average minutes of usage per week per user: 210 minutes in 1990; 210 minutes in 2000.
c. 11,200 bits per minute, based on two 700-character pages per minute (with 8 bits per character).

TABLE A-22. VIDEOTEX/TELETEXT TRAFFIC FORECAST
(terabits)

YEAR		
1980	1990	2000
.44	1835	6115

A.3.4.3 Telemonitoring

Telemonitoring is a term used to describe electronic monitoring from a central location of the status or condition of a device at a remote and usually unoccupied location.

Generally, telemonitoring falls into one of the following categories:

1. Security
2. Civil defense and government agencies that protect citizens
3. Utilities
4. Communications systems
5. Traffic control.

Security

Most burglar and fire alarm systems that presently use telemonitoring are provided by professional alarm installers. Most systems are simple fire/smoke alarms or entry switches that are triggered when an alarm condition occurs. A wire pair is connected to an alarm panel at a central monitoring location, generally the local police station. The cost is high. In the future, 40% of the nation's businesses and 98% of future cable TV (CATV) customers may be offered a low-cost means of protecting their property. Where interactive cable is available, the communications link to a central monitoring station is already in place. The alarm industry, naturally, is trying to keep CATV from providing this service, but it would be a simple matter for the security system operators to lease a communications link from the cable company.

The concept of CATV telemonitoring is that of a high-speed head-end computer which constantly polls all households connected to the system. Each household has a unique address. Each household responds with an "okay" status by means of a modem. If an alarm condition exists, the household modem then alerts the computer of the type of alarm: fire, illegal entry or emergency. At the central station, the computer receiving the alarm prints out the name and address of the household. The attendant then notifies the proper authorities.

CATV industry sources project a tremendous growth in demand for their services on the order of some 38 million subscribers by the year 2000 (see Table A-23). Some industry spokesmen believe it is even feasible to establish "super monitoring stations" in various locations to handle from one to ten or more states. Others maintain that security controls (see Figure A-1) are best handled by local monitoring stations where police, fire and emergency crews can respond on very short notice.

Civil Defense and Government Agencies

Nuclear explosion detectors operate in the following manner. Light waves strike the detector and give it time to respond with a "Red Alarm" before the nuclear shock waves arrive to destroy the device. The detectors are mounted in a circular fashion around a major target area; each has a completely different circuit route. Thus, if a direct hit occurs on one site, the other two sensors would be able to respond. (This system may no longer be in service -- classified information.)

Government agencies operate many types of monitoring devices. EPA's air pollution monitors are one example. There are more than 8,000 air pollution monitors located throughout the United States. About 10% of those are remotely monitored at present. Budget restrictions will probably necessitate 100% remote monitoring within the next few years.

Remote monitoring devices detect flood stages on rivers, earthquake tremors and other natural threats to life and property. No figures are available on these types of monitoring. On a more routine basis, remote weather monitors transmit barometric pressure, temperature readings and storm activity data for weather forecasters across the nation. (See also Traffic Control).

Utilities

The technology behind CATV security services also supports meter reading devices to monitor gas, electric and water usage. Reduced labor and transportation costs will certainly make this capability attractive to utility suppliers. In

TABLE A-23
PROJECTED GROWTH IN CABLE SERVICE SUBSCRIPTIONS

	1980		1990		2000	
TV Households (TVHH)	80,700,000	(2)	95,000,000	(3)	100,000	(4)
CABLE TV (CATV)	18,672,000	(2)	58,900,000	(2)	90,200,000	(5)
PERCENT TVHH WITH CABLE	24%	(2)	62%	(2)	82%	(5)
NUMBER OF TVHH WITH SECURITY SYSTEMS (1)	12,335		7,600,000		38,500,000	
PERCENT ESTIMATED TVHH PROJECTED	.015%		5 TO 10%		30 TO 40%	

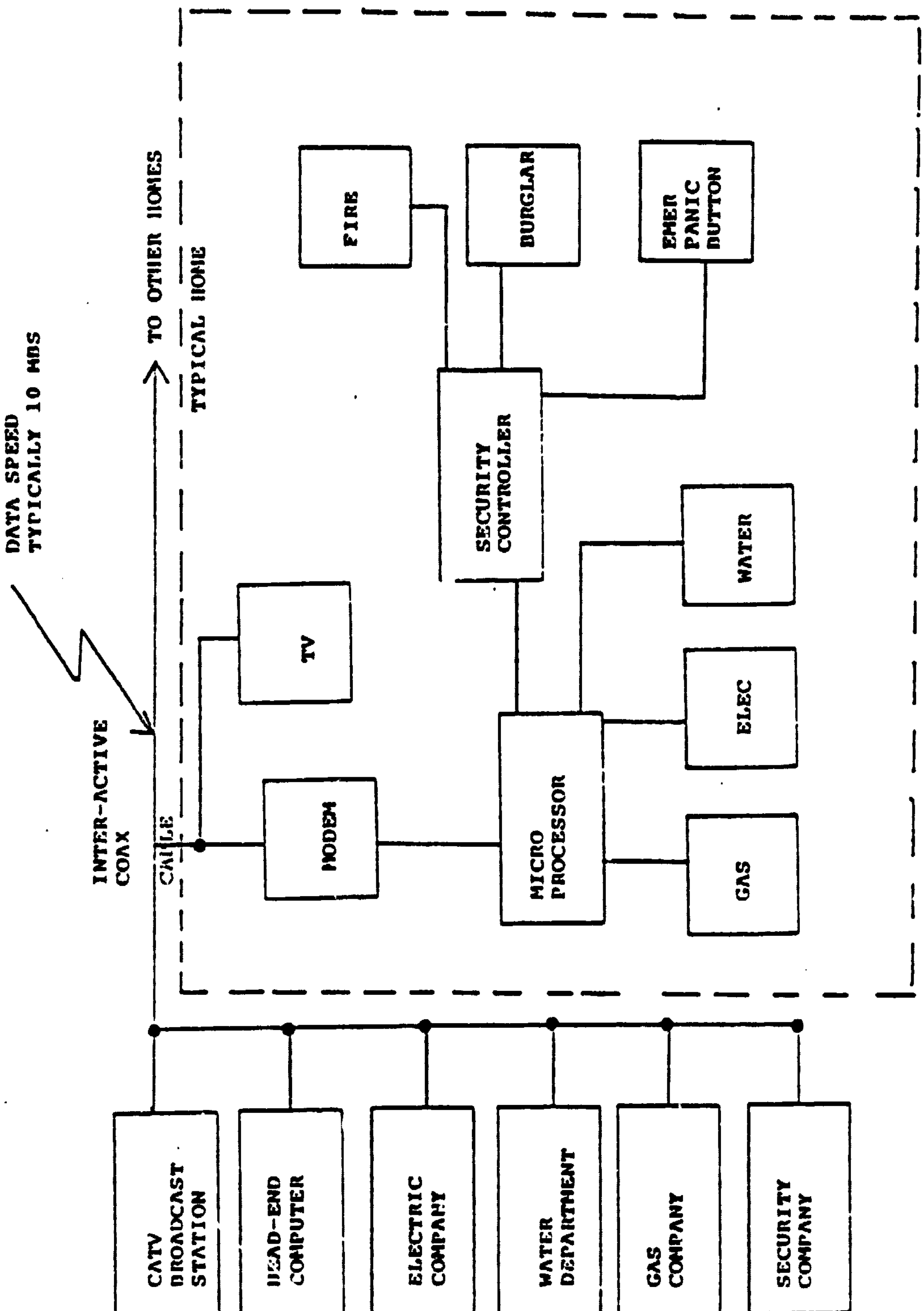

FIGURE A-1. SECURITY CONTROLS

some cases, utility information will be transmitted long distance to a state or regional office for billing purposes.

Communications Systems

Most communications systems, landline, microwave, or satellite, have built in testing which operates on a continuous basis. Remote unmanned building points, microwave stations or satellites have constant performance monitoring from a central office. Growth in this area is directly proportional to the overall growth projected in communications.

The TV industry is very concerned about viewing trends, as witnessed by the dependence on the Nielson Ratings. Thus, they could profit from the ability to build into their systems the means to determine what channel each subscriber is watching at any given time by a remote monitoring device. Summaries of that information could then be provided to suppliers of their programming.

Traffic Control

Air traffic control is perhaps the best example of a government monitoring system. All major airports have radar to monitor traffic and to radio landing and take-off instructions to pilots. Radar screens show the ground controller the flight paths of all air traffic. The flight controller advises the pilot on which altitude and direction to fly, in order to prevent collisions and promote air safety. There are approximately 20 Air Route Traffic Control Centers (ARTCCs) located throughout the United States. The ARTCCs are linked by telephone VFs to each area serviced by that control center. The sector covered by an ARTCC varies in size according to traffic density. There are seven centers along the East Coast: Nashua, New Hampshire; Ronkonkoma, New York; Leesburg, Virginia; Atlanta, Georgia; Jacksonville, Florida; and Miami, Florida. At each one, controllers are able to view airport radar sightings across their assigned territory. For example, a controller in Leesburg can remotely select a Norfolk radar scanner to obtain a visual screen of air traffic in that area.

Major changes are likely to occur in this system over the next 20 years. Clearly, the changes will involve more remote sensing of air traffic, possibly by satellite, along with further improvements in computers.

Another area of traffic control monitoring which has been proposed is the remote sensing of a vehicular accident. If all automobiles were required to have a beacon, that device could transmit an accident signal to a satellite, which in turn would notify the nearest authorities and save valuable minutes.

A.3.4.3.1 Baseline

The baseline (see Table A-24) for telemonitoring was derived based on interviews with industry sources about the different uses of telemonitoring and Western Union's own internal analysis using information such as that presented in Table A-23.

A.3.4.4 Secure Voice

Along with its many benefits, the age of electronics has provided the ability to intercept voice and data communcations for as little as several hundred dollars. Concurrent advancements in technology have facilitated eiectronic surveillance and interception of proprietary or sensitive information. Typical security threats include:

a. Organized and intentional attempts to obtain economic or proprietary information from the competition.

b. Determined attempts to obtain economic and sensitive information from government agencies dealing with the military and the private sector.

c. Fraud through illegal access to computer data banks, including Electronic Funds Transfer (EFT).

d. Intentional or unintentional destruction of computer data banks.

TABLE A-24. TELEMONITORING TRAFFIC FORECAST
(terabits)

YEAR		
1980	1990	2000
.1	.8	3.5

Since a significant portion of daily transactions occurs over the telephone, the replacement of telephone wires with microwave radio transmissions has created a condition in which information can be intercepted without requiring a "physical tap" on the telephone line; therefore, interception can be accomplished undetected.

Communications common carriers are the providers of a variety of telecommunications services and are operated as regulated monopolies. The lion's share of telecommunications, whether voice or data messages, is transmitted by the common carriers' systems. A typical network consists of some combination of land lines, microwave radio transmission systems (terrestrial and satellite) and undersea cables. In the United States, between 65 and 70% of all toll messages are carried by microwave radio facilities at some point along their route.

There are two basic forms of telephone service: Public Telephone Network (switched lines) and Private Line Service (dedicated lines). Dedicated private lines are always transmitted over the identical route, transmission facility and circuit. Similarly, the dedicated private line always occupies the identical segment of the radio spectrum. Therefore, once the interceptor "locates" the frequency of the dedicated circuit of interest, electronic equipment can monitor every message over that circuit.

With the dial-up network and switched private lines, the interceptor can select calls of interest, since each call is preceded by a signal identifying the telephone number being called. With the use of computers, the interceptor can easily monitor and selectively screen large volumes of messages; the computer simply searches for key words, names, subject titles and/or telephone numbers of interest. A computer can perform this task on digital data extremely rapidly.

In the case of voice communications, at least for now, technology is not well-developed enough to monitor large volumes of calls automatically except through use of the accompanying signaling information. With the recent and continuing advances in automatic speech recognition that employ word-spotting techniques, the expense of electronic interception of voice messages may be substantially reduced.

Communications security for voice and/or data messages requires the utilization of a variety of technologies depending upon specific application requirements. In voice communications there are two primary techniques:

1. scrambling of the analog voice signal, or;
2. converting the analog voice signal to digital form and then implementing any one of a variety of digital encryption techniques using standard cryptographic technology.

Voice scrambling and digital voice encryption techniques each have their own distinct characteristics.

In general, voice scramblers offer a significant "human factor" advantage, in that they can provide excellent speech quality and speaker recognition. However, this is offset by the fact that the level of security for voice scramblers is considered limited when compared with the strength of digital encryption techniques. On the other hand, digital voice encryption speech systems offer a significantly higher level of protection at the expense of speech quality and speaker recognition.

Analog scramblers modify the voice signal by changing the signal in the amplitude, time or frequency domains or any combination thereof. Typical scrambling methods include:

a. frequency inversion
b. bandsplitting
c. time division multiplexing.

There are two primary categories of voice scrambling systems:

1. Static systems allow the scrambling scheme (code) of the signal to remain constant during the course of the message transmission.

2. Dynamic systems constantly rearrange the code permutations throughout the duration of the transmission. The code could be

changed several or hundreds of times for each second of transmission time. Obviously, dynamic systems offer a higher level of protection, as they decrease ease of translation on the part of an unintended listener.

Digital voice protection systems convert the analog speech signal into an equivalent digital signal. Digital voice systems provide many advantages over analog methods in communications transmission. The significant advantage of digital voice systems is the high level of protection obtainable from a wide range of cryptographic techniques commonly used to protect data communications.

In converting the digital form back to the original analog signal, a voice synthesizer is used. Synthesis is merely an emulation of human speech by electronic means.

Once a digitized voice signal has been encrypted the level of protection is entirely dependent on the strength of the technique used to encrypt the digital voice signal.

A voice digitizer converts the analog speech signal into a digital data stream for subsequent enciphering and modulation when the terminal is transmitting, usually by:

1. Linear Predictive Coding (LPD) at the 2.4 kbps data rate
2. Adaptive Predictive Coding (APC) at a bit rate of 9.6 kbps.

Higher bit rates mean improved speech quality. Regardless of the voice digitizing function employed, the digital signal must be encrypted prior to transmission.

Cryptography is a proven, practical way to protect communication transmissions. There is a new type of analog scrambler which promises strategic protection. This device employs a technique of converting the analog signal to digital form, then applying cryptographic techniques to the digital signal with the resultant cipher text being converted back to analog form. The popular technique is to process the analog voice signals by continuously variable slope delta (CVSD)

modulation, which converts the signal to a digital data stream. The digital data is enciphered and then converted back to analog form by CVSD demodulation. The enciphered analog signal is transmitted over conventional voice-grade lines, with the reverse process occurring at the receiving end. These new hybrid devices offer a significantly higher level of protection than traditional voice scramblers, while enjoying the inherent operational advantages of analog systems.

To establish a level of protection for digital voice systems, an analysis of the various cryptographic methods available is necessary. Therefore, the relative strength of a data communications system depends on the strength of the encryption algorithm, how the algorithm was implemented into hardware, and key management.

The National Bureau of Standards has developed an encryption algorithm that has been approved by the Federal Government for certain information processing applications. The Data Encryption Standard (DES) provides protection for unclassified or proprietary information. About 50% of domestic vendors offer DES-based products.

Prospective users who may have classified or unclassified but possibly sensitive information that relates to, or borders on, national security concerns are advised to further discuss their protection requirements with the National Security Agency (NSA). NSA is the sole authority for protection of classified information which is transmitted electronically.

Presently, marketing studies show there are the following vendor-provided equipment available:

TECHNOLOGY		VENDORS	PRODUCTS
Voice Scrambler -	Analog (VS-A)*	20	80
Voice Encryption -	Narrowband (VE-N)	10	12
Voice Encryption -	Wideband (VE-N)	11	22

Data Encryption (DE)**	23	71

* Includes analog FAX.

** Includes digital FAX.

Generally, the various commercial and military applications of secured voice encryption devices are installed for use in one of the following manners:

1. acoustically coupled to the telephone.
2. base station installation (radio).
3. portable (radio or telephone).
4. vehicular (mobile radio).
5. directly wired (radio or telephone).

When devices are used on typical voice-grade telephone channels, the user can expect a 3 to 5 dB loss of "signal/voice" ratio which degrades speech quality. Additionally, many communications systems, particularly telephone systems, and mobile radio telephone systems, utilize a wide variety of signals in the form of tones which are transmitted continuously, intermittently or periodically.

Communications security devices must be utilized in a way which will neither interfere with the supervisory signals nor be interfered with by supervisory signals. Proper selection of a security device is not necessarily a question of choosing the most secure technique; rather, it is a process of selecting equipment that provides an adequate level of security with satisfactorily recovered voice quality and performance over the particular types of channels with which it will be used.

Due to the privacy constraints of users of communications privacy devices, it has been difficult to determine the quantity and volume of usage of secured voice devices and systems. However, making the following assumptions a forecast (see Table A-25) was determined.

1. FCC reported 26 billion messages per year, of which 52% were "business."
2. Business messages per year were multiplied by 100,000 bits per message.

TABLE A-25. SECURED VOICE TRAFFIC FORECAST
(terabits)

YEAR		
1981	1990	2000
5.2	157	894

3. It was estimated that .4% of the messages were encrypted.
4. The growth of encrypted messages to 1990 and 2000 was postulated.

A.3.5 Summary of Data Baseline Forecasts

A summary of the baseline forecasts for the specific data services and for all data services is presented in Table A-26. The corresponding growth rates for the 1980-1990 and 1990-2000 time periods are noted in Table A-27.

A.4 VIDEO APPLICATIONS

Video applications are divided into two sections, broadcast and limited broadcast. Broadcast services are transmitted to a large number of end users simultaneously. Limited broadcast is more directly aimed even though the number of users may still be quite large, as in the case of DBS. Video services are grouped below:

1. Broadcast
   a. Network Video
   b. CATV Video
   c. Occasional Video
   d. Recording Channel
2. Limited Broadcast
   a. Teleconferencing
   b. DBS/HDTV

The first set of services deals with broadcast applications. The steps used to establish the baseline for these services are as follows:

a. Determine the number of transponders used for commercial video, PBS, educational and occasional video.
b. Determine future plans for each of the services and project onward.

TABLE A-26. DATA BASELINE
(TERABITS)

SERVICE	1980	1990	2000
	YEAR		
Data Transfer	464.0	1400.0	6240.0
Batch Processing	304.0	912.0	1640.0
Data Entry	380.0	1960.0	7320.0
Remote Job Entry	165.0	1295.0	2320.0
Inquiry/Response	165.0	1295.0	3088.0
Timesharing	94.0	268.0	520.0
USPS/EMSS	0	338.4	996.8
Mailbox	.2	4.9	12.7
Administrative Traffic	48.5	300.0	933.0
Facsimile	235.5	543.7	1230.0
Communicating Word Processors	17.1	117.1	400.3
TWX/Telex	1.2	1.6	2.2
Mailgram/Telegram/ Money Orders	.4	.8	1.6
Point of Sale	12.0	214.4	360.0
Videotex/Teletext	.1	275.0	917.0
Telemonitoring Service	.1	.8	3.5
Secure Voice	5.2	157.0	894.0
TOTAL	1892.3	9083.7	26879.1

TABLE A-27. DATA BASELINE - GROWTH RATES (ANNUAL, %)

SERVICE	TIME PERIOD 1980-1990	1990-2000
Data Transfer	11.7	16.1
Batch Processing	11.6	6.0
Data Entry	28.1	14.1
Remote Job Entry	22.9	6.0
Inquiry/Response	22.9	9.1
Timesharing	11.0	6.9
USPS/EMSS	0.0	11.4
Mailbox	37.7	10.0
Administrative Traffic	19.6	12.1
Fascimile	7.5	8.5
Communicating Word Processors	21.2	13.1
TWX/Telex	2.9	3.2
Mailgram/Telegram/Money Orders	4.8	7.2
Videotex/Teletext	120.8	12.8
Telemonitoring Service	23.1	15.9
Secure Voice	40.6	19.0

This technique will give the net addressable satellite forecast which must then consider any potential impact factors.

To understand how each transponder is currently being used, FCC reports were reviewed to determine those satellites currently in use. To ascertain the future growth of network video three sources were used. First, all announced plans for future transponder use in trade magazines as well as new filings for satellite systems were reviewed. Second, the future of satellite transmission was discussed with industry representatives from CBS, PSSC and others. Third, the future of the industry was discussed internally with our experts. Western Union has prepared bids for both NBC and PBS on satellite use and is currently doing the distribution for PBS. Most of the WESTAR System is used either for cable or occasional television distribution.

For the other two services, teleconferencing and DBS/HDTV, a forecast was made only for teleconferencing. This was done using a vendor survey as well as industry studies. DBS/HDTV was treated as an impacting factor only since the FCC is likely to allocate use of spectrum outside those considered by this study.

A.4.1 Broadcast Services

The greatest use of satellites so far, outside of voice, has been with video applications. The reasons for this are the wide bandwidth required for video transmission and the need to reach a large number of locations throughout the United States. Western Union's initial study broke the video market down into three segments: network video, CATV distribution, and occasional video used by both the networks and CATV. Two new entrants have appeared recently which promise to add to the video explosion. They are direct broadcast services (DBS) and high definition television (HDTV). A brief description of each of these services is given before explaining the forecasting techniques used.

A.4.1.1 Network Video

Network video has traditionally used dedicated full time facilities for point to multipoint distribution. Since the introduction of satellites, the networks are doing more multipoint to multipoint distribution. For instance, ABC's Good

Morning America show originates in New York, the news spot is done from Washington, and the weather from Atlanta as well as feeds from throughout the U.S. for other portions of the show. Besides commercial television, other applications fall under network video and are prime candidates for satellite transmission, including Public Broadcasting Service (PBS) and the Educational Networks.

The commercial networks, ABC, CBS and NBC, offer free programming paid for via advertising. Currently, almost all regular broadcasting for the commercial networks is carried to affiliated stations via AT&T long lines microwave networks. However, recently all three networks have signed agreements with AT&T to begin satellite transmission of programming to affiliated stations. From that point, it is retransmitted or aired to the local community. PBS, on the other hand, operates by fund raisers, company donations and some government support (although it has applied to the FCC for permission to allow advertising). PBS also uses affiliated stations to rebroadcast; however, it uses satellites to distribute the information to those stations. Educational networks, funded largely by states, local governments and universities to provide classroom instruction to large audiences, have grown rapidly in the last decade. Although most of this is fairly local, it is likely that as networks join together to provide better training at less cost satellite distribution to local stations will grow. Three states, Indiana, Florida and Michigan, already use satellite transmission to meet their statewide educational goals.

A.4.1.2 CATV Video

CATV video comprises program originators other than networks, who video broadcast their programs on a part-time regional or national basis. Distribution networks usually include terrestrial (cable), microwave and satellite facilities. In the case of satellite distribution, affiliated small earth stations interconnect the space segment (leased by the distributor) and the cable head end.

As CATV continues to grow, the need for programming also will continue to grow. This demand is already seen in the fierce competition to gain transponder access. According to industry sources, cable is already connected to 25% of American households. Most large urban areas have not even been wired yet.

Areas such as Chicago and Dallas are very near and will add to the demand for programming. Thanks to cable, the market will continue to be segmented, with religious stations, black stations, public affairs stations and so on. Although this demand for programming will someday be saturated, this is not likely to occur until after 1990.

A.4.1.3 Occasional Video

Occasional video refers to event broadcasting such as news, sports events or movies. A large number of programmers use this type of transmission including the networks and various cable stations.

A number of companies, such as Wold or Satellite Syndicated Systems, offer this type of service for a few hours at a time, using remote hookups much of the time. Other uses for occasional video are continually being thought of. One example is horse racing. In Connecticut, a highly successful theater was built in 1979 which broadcasts live horse races. This idea has been picked up by entrepreneurs in Las Vegas who plan to broadcast these races live.

A.4.1.4 Recording Channel

Recently, CBS announced plans for a video recording channel. Material suitable for programming is transmitted to the home via cable during low usage hours (after 1:00 A.M.). The growth of video recorders and the desire for uninterrupted programming that can be recorded along with the lower cost associated with these hours makes this a desirable offering. Since transmission of this service occurs during off hours, we have not projected any transponder use for 1990. By the year 2000 one can expect that some recording channels will be offered during peak times or even 24 hours, based on the anticipated growth of video recorders.

A.4.1.4.1 Baseline

The method used in the previous study to establish the baseline forecast for this service was not used; that study determined the total amount of network traffic. It was decided that although nothing was wrong with this approach, a more

accurate technique would be to ascertain the actual number of transponders in use and their future growth rate. The steps used to establish the baseline are as follows:

a. Determine the number of transponders used for commercial video, PBS, educational and occasional video.
b. Determine future plans for each of the services and project onward.

This technique will give the net addressable satellite forecast, which must then consider any impact factors.

To determine how each transponder is being used, we went to the FCC and reviewed those satellites currently in use. To ascertain the future growth of network video three sources were used. First, all announced plans for future transponder use in trade magazines as well as new filings for satellite systems were reviewed[24,25,26,27,28,29]. Second, the future of satellite transmission was discussed with industry representatives from CBS, PSSC and others. Third, the future of the industry was discussed internally with Western Union staff. Western Union has prepared bids for both NBC and PBS on satellite use and are currently doing the distribution for PBS. Most of the WESTAR System is used either for cable or occasional distribution.

Compression of video signals is likely to occur in the early 1990s. This will not be accepted by everyone because of the high quality picture required. Other trends such as multilingual sound, stereo sound and high definition sound will also work against compression. Therefore, a factor of 1.5:1 was applied to calculate the expected number of transponders required. See Table A-28 for the 1980, 1990, and 2000 Broadcast Services forecasts.

A.4.2 Limited Broadcast

Broadcasting is meant to cover a very broad area; limited broadcasting is more directed. Two services are covered under limited broadcasting, teleconferencing and direct broadcast satellites/high definition television (DBS/HDTV). Teleconferencing is usually conceived as a meeting between two or more groups.

C - 2

DBS/HDTV is similar to broadcast TV although it is picked up by a rooftop antenna.

A.4.2.1 Video-Teleconferencing

Video-Teleconferencing is expected to be the driving force behind transponder demand from 1985 through the end of this century[24,25]. The basic purpose of video-teleconferencing is moving meetings to people, rather than people to meetings.

There are many variations of video-teleconferencing from fixed frame one-way video/two way audio, requiring simple phone lines, to high definition two-way video and audio, requiring a very large bandwidth. The number of sites involved may vary from two to dozens.

Video-Teleconferencing is just now entering its growth phase. A number of companies, including ARCO, MACOM and many others, have installed their own facilities to conduct video-teleconferences. Users report improved efficiency and increased cost effectiveness. As travel costs continue to rise and the cost of teleconferencing facilities declines, word of the success of video-teleconferences will inspire others to jump in.

Hotel chains are an example of this trend. Many major chains have established a network to handle video-teleconferences. They include:

Holiday Inn	Hyatt
Raddisson	Marriott
Hilton	

Besides the hotel industry, a large number of private companies now provide this service, including AT&T and SBS, and are pushing hard to expand their markets.

The three video-teleconferencing arrangements analyzed include:

a. Full motion
b. Limited motion
c. Fixed frame

TABLE A-28. BROADCAST SERVICES FORECAST
(36 MHz transponders)

	YEAR		
	1980	1990	2000*
Network			
Commercial	5	30	27
PBS	4	7	6
Educational	1	5	7
	9	42	40
CATV	34	76	57
Occasional	19	52	41
Recording Channel	0	0	2

* A compression factor of 1.5:1 was used in 2000.

Full Motion Video-Teleconferencing provides the most realistic conference atmosphere. It is, therefore, the most popular form of video-teleconferencing. It normally uses 22MHz of bandwidth and is often used in conjunction with high speed facsimile or another data link. Digital technology is the most likely form of transmission and a 2:1 compression ratio can be expected by 1985.

Limited Motion Video-Teleconferencing transmits a picture much as full motion does; however, gaps are apparent as the equipment waits for the next transmission. This type of conferencing is useful where one person does much of the presentation. Limited motion video conferencing can be done using 1.5, 3.1 or 6.3 Mbps facilities. Better motion, color and details occur at the higher transmission rates. Western Union engineering analysis indicates that approximately 12 limited motion conferences could be held per transponder.

Slow Motion Video-Teleconferencing is very useful where diagrams or charts are being presented and then discussed. This technique is useful with engineering drawings and shows promise for telemedicine. Although this type of conference can use between 1.2 kbps and 1.5 Mbps, it was assumed that the average conference uses 56 kbps. Using this average along with internal engineering analysis it was determined that an equivalent 50 Mbps transponder could handle 300 one way video conferences.

A.4.2.1.1 Baseline

In order to determine the demand for video conferencing, a number of steps were taken. The major ad hoc vendors (such as Tymnet and PSSC) were contacted and the following questions were asked:

1. In the last year, how many teleconferences has your organization done?
2. Were these conferences full, limited, or fixed frame?
3. Was the conference one-way video/two-way audio or two-way video/two-way audio?
4. On the average, how many sites were involved?
5. Over what distance was the conference usually held?

6. What was the typical length of the conference?
7. Was there a particular time of the day when conferences seemed to be held?
8. What type of growth do you feel will occur in teleconferencing in the next five years?
9. What are the prospects after that?
10. Do you have any other comments you would care to make?

The information from the vendor survey was weighted carefully considering the audience contacted. The survey included vendors providing large conferences, with the average size of a conference covering 15-20 sites. Most of these conferences were one-way video/multi-way audio and lasted two to three hours. Because of the large geographical areas covered, time differences had to be considered. Therefore, conferences generally began between 10 a.m. and 8 p.m. Eastern Standard Time, with 2 p.m. being the most popular time. The following is a summary of these interviews.

> Video teleconferencing is a service that has a great potential for growth over the next few years. The possible applications are tremendous, both on an ad hoc basis for one-time conferences and in the context of a dedicated system serving the internal communication needs of a single business entity.
>
> Most teleconferencing today is full motion (rather than slow scan type) with one-way video and two-way audio hook-ups. As technology improves, becoming more familiar and less costly, we can anticipate a wider use of two-way video and audio teleconferencing.
>
> Any number of sites may be involved in a teleconference, depending greatly on the needs of a particular customer and the purpose to be served. The number of sites ranges from one to hundreds on a national and/or international scale. The average seems to be in the 15 to 25-site range, making a teleconference an economically feasible alternative to travel.
>
> As a rule, a teleconference links a widely disparate geographical area which usually includes both east and west coasts. There is some tendency to cluster in large population areas along the west coast or the northeast corridor of the U.S. Teleconferencing can be useful in linking various regions, but is not often a factor within a very regional framework due to cost factors.

Most teleconferences last about two to three hours, although this is another factor which varies widely according to need. Typically, the actual time devoted to teleconferencing is padded somewhat by time spent in educating the participants in the most effective methods for using a relatively new service.

Given the geographical range of areas covered and differing time zones nationally and internationally, timing becomes a factor in planning which cannot be ignored. Teleconferencing between east and west coasts tends to center between 10:00 A.M. and 2:00 P.M. in order to compensate for time differences and to keep the teleconference within business hours. This problem grows more acute as the teleconference takes on an international rather than a purely national aspect.

Another limitation to be considered is the availability of transponder time to the organizations arranging teleconferencing. Limited transponder availability also dictates to what extent a customer may choose the day and time of the proposed teleconference. A fully dedicated system or continuous access to transponder use obviously makes teleconferencing a more flexible tool enjoyed by relatively few users at the present time. There are expected to be substantially more transponders available by 1985 (and/or transponders with greater capacity) which should alleviate the problem of transponder time. That should, in turn, make teleconferencing a more economically sound, less costly service, thereby opening up the market for ad hoc use of teleconferencing to smaller concerns who could not presently afford it.

One scenario for the growth of teleconferencing sees an explosive growth rate in ad hoc use of teleconferencing over the next couple of years (as much as 100% per year for 5 years) gradually tapering off. As familiarity increases and technology improves, teleconferencing will become a business necessity for large nationwide users, resulting in a less dramatic, though steadily increasing (25%) and continued growth rate as more dedicated systems are implemented. Eventually, the dedicated system will be the more widely used, despite the growth spurt in ad hoc use that has developed over the past couple of years and will probably continue for the next few years.

At the moment, there seem to be about 140 teleconferences (as an average) held on a yearly basis. This figure is constantly increasing and will continue to do so. Several factors enter into the actual planning of a teleconference. There is a need to familiarize the client with the technology itself so as to put it to its most effective use and to respond to that client's real needs. The cost factor is a consideration; so is availability of transponder time: all of which suggests a preferred lead time of six months. Teleconferencing can be done, and done successfully, in much less time given the appropriate set of circumstances. It does, however, require a certain amount of preparation to be most effective. Another consideration is the

importance of social interaction. One benefit of teleconferencing is the ability to make those in more remote sites feel they are actually participating in the meeting and/or decision-making process. This sense of immediacy must be balanced against the trend of social interaction which results from informal contacts made when all conference participants are in the same location.

The AT&T and SBS filings which discuss teleconferencing were reviewed. Current literature discussing the service and its use was also reviewed as well as many of the studies performed by industry analysts. Information provided by vendors and the user survey enabled us to establish the actual number of conferences held in 1980. All sources combined were used to determine a forecast for 1990 and 2000.

After determining the forecast, the results were discussed with Western Union's product line people who are about to enter this field. The results were then modified to reflect their input and are presented below.

For the purpose of presenting the data on video-teleconferencing, teleconferences have been divided them into "public" and "private" teleconferences. Public use consists of those who provide transmission capability and teleconferencing facilities as a service to the general public. Generally, this means a one-time conference held by a private company or organization that does not have its own facilities available. One example is AT&T's new Picture Meeting Service (PMS). Private teleconferencing, therefore, consists of any dedicated or in-house system. Private companies and Government agencies fall under this definition. SBS is a leading example of a private teleconferencing system.

The current number of teleconferencing rooms was obtained through the literature search. Approximately 12 private rooms and 30 public rooms are all used on a limited basis. Future rooms were projected based on the AT&T Picture Meeting Service (PMS) tariff filing, interviews with vendors and other industry literature.

ROOMS	1980	1990	2000
Private	12	4287	13,963
Public	30	500	900

To show that the numbers are reasonable, one can take a year and look at the tariff filings. For instance, estimates from AT&T and SBS indicate that around 2,100 public rooms will be in use by 1985. Also, 4,500 private rooms are projected for 1990 using other industry sources. Discussions with CODEC (makers of compression equipment which allows you to hold a video conference at a very economical cost) indicate that as the quality of their equipment improves and the cost continues to come down, the growth rate for new rooms will increase dramatically. Average daily use is projected in hours as:

DAILY USE (hours)	1980	1990	2000
Private	5	4	3
Public	1	5	4

Initially, private rooms will be installed in heavy usage areas. Public and remote rooms include the PMS service and ad hoc meeting rooms (only rooms with uplinks are counted). As the number of private rooms grows, less heavily used rooms will be counted, thus bringing the average daily usage down. Heavy advertising, competition and the realization by many businesses that video conferencing can pay will lead to a much heavier use of public rooms by 1990. The average daily use figure will decline by 2000 because of competition and the proliferation of less heavily used rooms.

Average conference length as well as the average number of rooms per conference can be projected based on the results of surveys conducted by AT&T, SBS and Western Union.

LENGTH (hours)	1980	1990	2000
Private	3.0	2.0	2.0
Public	4.0	2.5	2.0

ROOMS (Per Conference)			
Private	2.5	2.3	2.1
Public	4.0	4.0	4.0

Conferences tend to get shorter as more people become familiar with the technology and as rooms are made available for more spur-of-the-moment conferences. Public conferences tend to be longer because the topics are often broader with greater potential impact. Thus, the company sees the importance of making arrangements to hold a conference in order to include as many views as possible in its decision-making function.

It is possible to project the number of conferences by using the projected number of rooms, the length of an average conference, average daily use and the number of rooms per conference. The formula used is explained below.

Step		Procedure
find number of	start	number of conference room
conferences given	-	number of conference rooms/conference
at any one time	=	conferences (at any given time)
determine the	x	hours per day of use
number of	=	conference hours per day of use
conferences	-	conference hours/conference
per day	=	conferences per day of use
determine the		
number of con-	x	number of days of use per year
ferences per	=	conferences per year
year		

NUMBER OF CONFERENCES	1980	1990	2000
Private	2,083	932,065	2,493,452
Public	488	62,500	112,500
Total	2,571	994,565	2,605,952

Converting this value to the number of transponders required to handle the teleconferencing traffic requires some projections about the type of conference to be held. Our interviews revealed that full motion was desired by a number of organizations but the cost was prohibitive. This problem is expected to be solved by the introduction of high quality compression equipment (transmitting between 1.5 and 6.3MBPS) by the mid-1980s. Another trend our surveys showed was toward dedicated facilities. Many of these would operate both at limited and full motion video and include such things as high speed facsimile or electronic blackboards.

TYPE OF CONFERENCE	% in 1980	% in 1990	% in 2000
2 way full motion 2 way audio	30	5	1
1 way full motion 2 way audio	50	10	3
2 way limited motion 2 way audio	5	60	68
1 way limited motion 2 way audio	0	5	8
fixed frame	15	20	20

To determine the number of transponder hours required to handle traffic, multiply the total number of conferences by the percentage of each type of conference held (A) (see Table A-29). Next divide this by the total number of conferences an equivalent 50MBPS transponder can carry (B). Then divide the conferences into private and public (C). Multiply this by the average length of the conference to get transponder hours (D and E). Estimate the amount of traffic likely to go over satellite (F). This estimate is based on case studies of current systems as well as future tariff estimates and the lowering of the crossover distance. Multiplying the number of transponder hours (E) by the traffic likely to go over satellite (F) gives the number of transponders required (G). Then estimate additional compression of the video signals (H) and apply this (I). Divide this by the number of hours in the typical work year available to video conference (J). This is based on 250 work days consisting of a five hour day. Factors such as the time zone effect and reluctance to have either very early or very late business meetings were considered in selecting a five hour

work day. Peaking factors were applied in step K. An industry report cites 2.5 as the peaking factor in the 1980 to 1985 time frame. Our interviews led us to conclude this was a reasonable premise. In the future, as more sites are added and more impromptu conferences are held, this figure is likely to decline (1.2 was used in 1990 and the traffic was constant over the main 5 hours in 2000).

A.4.2.2 Direct Broadcasting Service/High-Definition Television

Direct Broadcasting Service (DBS) is the direct reception of video or audio signals from satellites to individual receiving antennas, thereby bypassing terrestrial transmission and receiving stations[26,27,28,29,30,31].

DBS provides an exceedingly flexible, distance-insensitive means of transmission with the potential of reaching geographical areas which are difficult or impossible to reach by terrestrial distribution networks. This factor is important when considering the difficulties of providing an equitable distribution of comunications services between rural and urban areas of the country.

Rural communications can be substantially enhanced by the use of direct broadcasting services which can succcessfully transmit a smorgasboard of communications services in an efficient, cost-effective manner. Special interest television, commercial and non-commercial television, information services such as teletext, store-and-forward message systems, educational and public service programming are just a few of the telecommunications services which can be provided by a direct broadcasting service.

One disadvantage of DBS that has been suggested is that it would result in a lessening of local service: one of the underlying concepts of the 1934 Communications Act was to encourage local ownership of broadcasting facilities and local programming to satisfy community needs.

Existing technology is sufficient to implement a DBS System: all indications are that DBS will become more economically feasible as the technology develops. The cost of a receiving antenna has already decreased and will continue to do so as DBS becomes a widespread reality.

TABLE A-29. VIDEO-TELECONFERENCING FORECASTS

	1980	1990	2000
A. TYPE OF CONFERENCE			
2 way full motion	771	49,728	26,059
1 way full motion	1,286	99,457	78,179
2 way limited motion	129	596,739	1,772,047
1 way limited motion	0	49,728	208,477
fixed frame	386	198,913	521,190
B. TYPE OF CONFERENCE			
2 way full motion	771	49,728	26,059
1 way full motion	643	49,728	39,090
2 way limited motion	22	99,457	295,341
1 way limited motion	0	4,144	17,373
fixed frame	2	663	1,737
C. TYPE OF CONFERENCE			
PRIVATE:			
2 way full motion	625	46,603	24,934
1 way full motion	521	46,603	37,402
2 way limited motion	18	93,191	282,591
1 way limited motion	0	3,883	16,623
fixed frame	2	623	1,662
PUBLIC:			
2 way full motion	146	3,125	1,125
1 way full motion	122	3,125	1,688
2 way limited motion	4	6,250	12,751
1 way limited motion	0	261	750
fixed frame	0	40	75

D. TRANSPONDER HOURS PER TYPE OF CONFERENCE			
PRIVATE:			
2 way full motion	1,875	93,206	49,876
1 way full motion	1,563	93,206	74,818
2 way limited motion	54	186,414	565,454
1 way limited motion	0	7,766	33,252
fixed frame	6	1,246	2,324
PUBLIC:			
2 way full motion	584	7,833	2,250
1 way full motion	488	7,833	3,376
2 way limited motion	16	15,625	25,228
1 way limited motion	0	653	1,500
fixed frame	0	100	150
E. TOTAL TRANSPONDER HOURS ALL CONFERENCES	4,586	414,380	759,206
F. PERCENT OF TRAFFIC CARRIED VIA SATELLITE	33	70	85
G. TRANSPONDER HOURS REQUIRED FOR SATELLITE TRAFFIC	1,513	290,066	645,325
H. FUTURE VIDEO COMPRESSION	1:1	2:1	3:1
I. TRANSPONDER HOURS REQUIRED CONSIDERING COMPRESSION	1,513	145.033	215,108
J. TRANSPONDER HOURS REQUIRED DURING BUSINESS DAY	6.1	580.1	860.4
K. TRANSPONDERS REQUIRED FOR PEAK HOUR	3	139	172

The "footprint" of the transmission may be either broad beam, covering a large geographical area or a spot beam, focusing in on a more specific location. The power of the transmission and the geographical area targeted determines the size of the receiving antenna, the "dish". The signal can then be retransmitted terrestrially by microwave or a similar system, although it is usually thought of as direct-to-house transmission.

The earth terminal is a major factor in direct broadcasting as it is the equipment which picks up the satellite signal, amplifies it, and remodulates it for reception on television sets. Beyond conventional television reception, direct broadcasting service could also be the transmission mode for high-definition television (HDTV).

HDTV uses a much wider bandwith for transmission of a 1,125 line system that gives a much clearer television picture on a large screen than currently seen from the 525/625 line system used in conventional television broadcasting.

Japan, several European countries, and Canada have already experimented successfully with a direct broadcasting system. In the United States, the FCC is considering deregulation of the cable industry which will have a great impact on the eventual development of DBS. There have been nine applications accepted by the FCC for permission to implement a DBS System (RCA, CBS, Western Union, Focus, STC, DBSC, Graphic, VSS and USSB) even given the high risks and high costs of first time entry into the market. Full implementation depends on economic conditions, market conditions and launch schedules over the next several years. Only 3 of the 9 proposals have indicated any preliminary launch dates, starting in late 1985/1986. At the present, we could anticipate that around 25 satellites dedicated to DBS would be operational around 1990 upon full implementation of these 9 proposals.

Comsat's DBS (STC) proposal envisions 6 satellites with four operational and two in-orbit spares, the first to be operational by 1985, marketed in areas where no cable or limited programming is available. It will be essentially a subscription TV service with three channels: one with major motion pictures, concerts, and stage productions; one with children's programming' and one with sports, adult

educational and experimental theater. The Comsat system will require a 30" antenna at a cost of around $500.00.

CBS has filed a DBS proposal to dedicate the entire DBS system to HDTV, a proposition which finds little support among DBS applicants who see it as an inefficient use of available spectrum.

HDTV requires a channel width of 27MHz and may even go to 70MHz for optimum use. The CBS HDTV proposal would transmit 1,125 line HDTV signals to and from the satellite, requiring more power and a 150MHz channel. This requirement would use a whole spectrum at 12GHz. It has been suggested that it may be compatible with the Comsat DBS (STC) proposal by compressing HDTV signals to 50MHz. Increased transmission power in this satellite range enhances the ability to receive the transmission with a relatively uncomplicated small "dish." This factor, in turn, makes individual home reception a feasible and effective use of DBS for the individual homeowner, hotel/motel manager, institutions, educational institutional, apartment building, condos, and others.

There has been little coordination in the Western Hemisphere in terms of allocating spectrum space for DBS, despite Canada's early use of a DBS System. Nor is there likely to be any decision before the 1983 World Radio Conference for Region II, North and South America. That conference will allocate spectrum for direct broadcasting service. Direct broadcasting service will transmit on Ku-band by international agreement, and will most likely be in accordance with standards set up by the 1977 WARC. There has also been an attempt to get the FCC to allocate a bandwith of the spectrum for DBS. Currently, DBS is expected to operate between 12.2 and 12.7GHz, a bandwidth allocated to fixed satellite service (FSS).

Because the eventuality of a separate frequency allocation by ITU (International Telecommunications Union) and the FCC is very likely and since the frequency is outside of that used for other satellite transmissions, there is no need to include a traffic estimate in this study. DBS will not replace TV transmission methods, but will compete by providing unique features of delivery and service, very similar to pay TV. The impact of DBS and HDTV on sevices forecasted will be determined by the effect of market determinant factors.

A.4.3 Summary of Video Baseline Forecasts

The baseline forecasts for the specific video services and for all video services are presented in Table A-30. The corresponding growth rates are indicated in Table A-31.

A.5 TRAFFIC NOT ADDRESSED

As we determined the baseline, it became obvious that large segments of traffic going through the United States' satellites may not have been counted. The strong ties between United States and Canadian business interests will certainly mean that large amounts of voice, data and video traffic will be carried between the two countries. Until recently, the only traffic between the two was carried over microwave. Video piracy of cable transmissions has altered this, though, and with introduction of DBS and a host of business services, it seems likely that the barriers to transborder communications will fall. The large Spanish-speaking population centers in the United States and the recent oil connections between the United States and Mexico mean that more information will flow that way, also.

Other traffic not considered but which may be significant is traffic to Hawaii, Alaska, and Puerto Rico. Much of this traffic will be handled on satellites viewed by the 49 continental states, and thus should be considered.

Transcontinental traffic which is international has also not been considered. Communications between Chicago and London, for instance, may very well double hop and therefore will use a domestic transponder. It is very easy to conceive of information going to South America moving through domestic transponders; for example, communications between Washington and Buenos Aires.

It is very difficult to estimate the current volume of this traffic. Each service would have to be examined and the amount of traffic determined. Since a large portion of this traffic would be long distance, it may have a significant impact on the number of transponders required in 1990 and 2000.

TABLE A-30. VIDEO BASELINE (TRANSPONDERS)

	YEAR		
SERVICE	1980	1990	2000
Network	10	42	40
CATV	34	76	57
Occasional	19	52	41
Recording Channel	0	0	2
Teleconferencing	3	139	172
TOTAL	66	309	312

TABLE A-31. VIDEO BASELINE - GROWTH RATES (%, Annual)*

SERVICE	TIME PERIOD 1980-1990	1990-2000
Network	15.4	0.5
CATV	8.4	2.8
Occasional (Video)	10.6	2.3
Recording Channel	0.0	0.0
Teleconferencing	46.7	2.2

*The low or negative growth rates for video services is due to expected compression.

A.6 CONFIDENCE INTERVAL

As stated in the introduction to the baseline section, it is difficult to project the baseline traffic demand out to 1990 and 2000. Even determining 1980 traffic demand is somewhat hard. Obviously, some services are easier to forecast than others. For example, message toll service has 25 years of historical information plus numerous studies by AT&T and other traffic engineers, making it fairly easy to project. Others, such as monitoring or teleconferencing services, are only in their infancy and thus are more difficult to project. This degree of difficulty can be stated as the "confidence interval" for Western Union's baseline forecast.

Confidence interval is defined for this study as the percent of variance that one could reasonably expect from the stated baseline forecast. It is stated as a percent of the baseline forecast traffic in either the plus or minus direction. Thus, for mobile radio, with a confidence interval of 5 in 1980, the traffic may be stated as 1.4 thousand half-voice circuits $\pm 5\%$. The confidence level for each service for each year are presented in Table A-32.

Four factors went into determining the confidence interval assigned to each service. First, the source of the information was evaluated. If the information came from the FCC or other government statistics, it was considered the best information available. Industry and user sources were considered the next most reliable, followed by internal Western Union studies and finally by independent analysis by research groups were also important resources. All sources were found to be valuable, but a ranking was necessary to estimate confidence intervals. Second, the logic of the projection technique was considered. In other words, did factors fit together and flow logically from the source of the projection to the traffic numbers or were a number of assumptions made. The third factor was the consistency and the number of other reports we were able to compare our estimates with. Often we found several reports on the same service using different techniques and arriving at different results. The fourth and final factor was an internal critique by Western Union's Marketing Research Department, its Product Line Managers, Traffic Engineers, and others.

Determining the confidence level not only shows the level of difficulty in making individual service projections, but also reflects the overall confidence one can

TABLE A-32. CONFIDENCE LEVELS

VOICE	1980	1990	2000
MTS (Business)	2	7	12
MTS (Residential)	3	8	13
Private Line	5	10	15
Mobile	2	7	12
Public Radio	2	7	12
Commercial and Religious Radio	5	10	15
Occasional Radio	5	10	20
CATV Music	2	7	15
Recording Channel	0	0	50

DATA	1980	1990	2000
Data Transfer	10	20	25
Batch Processing	10	20	25
Data Entry	10	20	25
Remote Job	10	20	25
Inquiry/Response	10	20	25
Timesharing	10	20	25
USPS/EMSS	0	10	15
Mailbox	5	15	20
Administrative Messages	5	10	20
Facsimile	8	15	20
Communicating Word Processors	5	10	15
TWX/Telex	2	7	12
Mailgram/Telegram/Money Orders	2	7	12
Point of Sale	15	25	40
Monitoring Service	15	25	50
Videotex/Teletext	5	20	30

TABLE A-32. CONFIDENCE LEVELS CONTINUED

VIDEO	1980	1990	2000
Network	1	5	10
CATV	2	6	10
Occasional	3	8	13
Recording Channel	0	0	50
Teleconferencing	2	10	20

have in the overall baseline forecast. This can be done by first multiplying the confidence interval times the percent of traffic each service has in terms of voice, video and data. Since it is difficult to put everything into common units at this point, the best way to get an idea of the overall confidence level of the baseline forecast is to weigh the overall confidence interval for voice, video and data by their respective percentages in Western Union's last report (reference 8).

Another advantage of using confidence levels is the ease of determining an upper and a lower bound for the expected traffic. This is done by weighting each service by the confidence level, then adding them to produce the ranges for voice, video and data.

In no case should the confidence level be confused with the market determinant factors. Confidence level only reflects the difficulty of forecasting, while market determinant factors are future events which will impact individual services.

A.7 SUMMARY OF BASELINE FORECASTS

A summary of the baseline forecasts for voice, data and video and of the corresponding growth rates from 1980 to 2000 is presented in Table A-33.

TABLE A-33. SUMMARY CHARTS

FORECAST	YEAR 1980	YEAR 1990	YEAR 2000
SERVICE			
Voice (10^3 half-voice circuits)	2828.9	8045.3	18405.3
Data (terabits)	1892.3	9083.7	26879.1
Video (transponders)	66	307	312

GROWTH RATE, (Annual, %)	TIME PERIOD 1980-1990	TIME PERIOD 1990-2000	TIME PERIOD 1980-2000
SERVICE			
Voice	11.0	8.6	9.8
Data	17.0	11.5	14.2
Video	16.7	.1	8.1

A.8 REFERENCES

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APPENDIX B

IMPACTED BASELINE FORECASTS

B.1 INTRODUCTION

The impacted baseline forecasts were developed by refining the baseline forecasts. As noted earlier, the baseline forecasts for each service were projections of the current and future volume of traffic. The baseline forecasts were scenarios reflecting the occurrence of expected events and orderly growth and the results of a cross impact analysis which eliminated duplicate demand. The impacted baseline forecasts were made by considering the impact of less predictable events or market determinant factors on the baseline forecasts.

B.2 THE IMPACTED BASELINE MODEL

The Western Union impacted baseline model is designed to refine, update and adjust forecasts. The following can be changed at any time:

a. The number of MDFs or services
b. The event probabilities
c. The cross-impact of the events
d. The impact of the events on the services

Two techniques for calculating the impacted baseline forecasts are built into the model:

a. The multiplication method--impacts of an event on events or an event on services for a particular year are calculated by multiplying the event's probability for that year by its total impact. The event is treated as if it partially occurred.
b. The random-all-or-none method--the event's probability and a random number generator are used to determine whether or not the event occurs in a particular year. The event is treated as occurring completely or not at all and its impacts are treated accordingly. The multiplication method approximates the

average of all possible scenarios developed by the random method.

For this report, the multiplication method was employed and its use is reflected in the analysis discussed below. However, the random-all-or-none method can be employed at any time to examine the variety of scenarios possible. Either method can be employed to conduct sensitivity analyses. Most importantly, the model can be employed to develop a variety of scenarios which can be used in strategic and long-range planning.

B.3 MARKET DETERMINANT FACTORS (EVENTS)

A Market Determinant Factor (MDF) or event was selected if it had the potential to impact the long haul market, significantly, uniquely and somewhat unexpectedly by 2000. In addition to these criteria, the matrix in Table B-1, a review of current literature and interviews with experts guided the selection of MDFs.

The matrix in Table B-1 indicates the event or MDF classes and the different impact areas for each MDF. The event classes were technological, economic and social-political and the impact areas were cost, availability, ease of use and need. An event could impact cost by making the cost of a service go down or the cost of a competing means go up; it could impact availability by making it possible to provide more of a service or to provide the service to more people; it could impact ease of use by making a service easier to use or by making a service more acceptable; and it could impact need by creating either a greater need for an existing service or a new need for the service. As a pool of MDFs was generated, effort was made to make certain that each event class was well represented and that each potential event might have at least one of the eight different impacts.

Through a comprehensive literature review and interviews with key providers, users and consultants, 36 events were identified. These events are defined briefly in Table B-2. The list of events should be considered representative of potential MDFs and should not be considered inclusive.

B.4 COLLECTION OF DATA

In-person interviews (15) were conducted with representatives of major carriers, providers, users, consulting groups, Federal agencies and Western Union Personnel to obtain information on the probability, timing and impact of each MDF. Interviewees were asked to estimate when (i.e., the year) each event would have a 10 percent or slim chance, a 50/50 chance, and an almost certain or 100% chance of occurring. They were also asked to indicate their level of confidence in making their estimates. The data collection form used to record this information on probability of occurrences of the MDFs appears in Table B-3.

Interviewees were then asked to estimate the potential impact of each of these events on the 31 specific voice, data and video services. They were also asked to note, if possible, what the event would impact: cost, availability, ease of use or need. As with the information on probabilities, interviewees were asked to indicate the level of confidence in making their estimates of impact. The data collection form used to record this information appears in Table B-4.

In addition to data on probability, timing and impact of MDFs, Western Union personnel estimated the cross-impact of the MDFs to provide a measure of the interaction of the various events. The data collection form used for this purpose appears in Table B-5.

B.5 ANALYSIS OF DATA

The first steps of data analysis involved calculating the probability of occurrence of each event for each year from 1980 through 2000. The mean year of occurrence of each event was determined for 10% chance, 50/50 chance and 100%/certain chance. The results of this analysis appear in Table B-6. Twenty-eight of the 36 events were judged to have a nearly certain chance of occurring by the year 2000. Biochips was the event least likely to occur by the year 2000, while voice-store-and-forward and a communications business shake down were the most likely to occur by 2000. Using straight line interpolation up to the year when the event chance was 100 percent, these results were transformed to provide the probability of occurrence of each event for each year from the year of 10 percent chance through the year of 100 percent chance. Then the

probabilities for each event were normalized. The normalized probabilities for each event for the 1980-2000 time period appear in Table B-7.

Next, the effects of the event cross-impacts (i.e., the impacts of events on each other's probabilities of occurrence) were calculated. The 1 to 3 cross-impact ratings appear in Table B-8. The most influential events, in terms of their impacts on other events, were the events involving advanced computer technology, prosperity-depression, national resources and attitudes about technology. Also, the technology-transmission events tended to impact one another as did the economic events. The 1 to 3 cross-impact ratings were converted to 0 to 2 cross-impact scores using the scale on the cross impact data collection form. Then the normalized event probabilities were converted to odds using the following formula:

$$\text{Odds} = \frac{\text{Probability}}{(1\text{-Probability})} = \frac{\text{\# Times expected to occur}}{\text{\# Times expected not to occur}}$$

The odds for an event for a particular year were then multiplied by the cross-impact score of a second impacting event, giving the new odds for the first event. The new odds were then converted back to a probability using the following formula:

$$\text{Probability} = \frac{\text{Odds}}{(1 + \text{Odds})}$$

The difference between the old and new probabilities was the total amount of impact made by the second event on the first. To get the amount of impact for each year, the normalized probability for the second event for each year was multiplied times the difference in probability of the first event. These steps were repeated for all events and for all years. The sum of the impacts on an event's probability for a particular year was then added to the event's probability for that year. This step was repeated for all years and the probabilities for an event were again normalized. These modified normalized probabilities appear in Table B-9. The difference between the probabiliies in Table B-7 and Table B-9 reflect the cross-impacts of the MDFs. In general, a consideration of these impacts increased the probabilities of the various events.

The next major step involved calculating the impacts of the events on the individual services. The mean impacts of events on services were calculated, and the Western Union personnel reviewed and modified these results so they would reflect considerations made when developing the baseline forecasts. The results of the modified impacts appear in the MDF-by-Service Matrix in Table B-10.

Then these impacts and the modified normalized event probabilities were used to determine the impacted baseline forecast for each service for each year from 1980 through 2000. For a particular service for a particular year, the probability of each MDF was multiplied times its impact on the particular service, and the sum of these impacts were added to the baseline forecast for the particular service. These steps were repeated for each year and for each service.

The data on confidence of estimates and on the type of impact (e.g., on cost) events might have on services were not reported. All interviewees rated themselves around average and indicated that their specific confidence levels ranged from very low to very high, suggesting that the ratings of confidence must be item-specific to be of any value. Interviewees did not have sufficient time to record the type of impacts events had on services.

B.6 IMPACTED BASELINE FORECAST

The impacted baseline forecasts for each service for each year appear in Table B-11. The differences between the baseline and impacted baseline forecasts were calculated as percent changes in the baselines and these differences appear on Table B-12. Much of the impact of the MDFs on the services does not occur until the 1990 to 2000 decade and this impact varies from a -1.5 to an 18.6 percent in 1990 and from a -1.9 percent to 37.2 percent in 2000. For the years 1990 and 2000, voice changed two and eight percent, data changed eight and 16 percent and video changed nine and 27 percent, respectively. The largest change (37 percent) occurred in video teleconferencing and videotext in 2000.

TABLE B-1

GUIDE FOR SELECTING EVENTS (MDFs)

Criteria: Must impact long haul market, significantly, uniquely, somewhat unexpectedly, I / 2000

IMPACT AREAS[1] / EVENT CLASS[2]	COST		AVAILABILITY		EASE OF USE		NEED	
	Goes down	Compet Means Goes Up	More of Service	To More People	Easier to Use	Made More Accept.	Greater Need for Service	New Need
TECHNOLOGICAL								
ECONOMIC								
SOCIAL-POLITICAL								

1. Impact areas are areas that, when impacted, will cause people to use more/less of the services; areas used to generate and document impact of events.

2. Event classes are simply three categories used to generate/group events.

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TABLE B-2
EVENTS-MARKET DETERMINANT FACTORS

TECHNOLOGICAL

Input

Touch Input Devices:
Widespread use of inexpensive screens/tablets that respond to touch.

Smart Cards:
Plastic microcomputer "smart cards" which are programmable are used extensively in financial transactions.

Voice Recognition:
Inexpensive, voice-recognition devices (e.g., voicewriter that can recognize instructions from spoken voice) become available and are used widely for computer time-sharing and office and home terminals.

Hand-held Terminals:
Widespread use of low cost hand-held terminals that can communicate with a network of computers.

Output

Non-Impact Printing:
Non-impact printing techniques (e.g., thermal processes) replace impact printer for hard copy production.

Flat Output Panels:
Flat, solid-state panels (e.g., plasma panels) replace CRT for soft copy production.

Processing

Microprocessors:
100,000 components per chip, 1 millionth of a meter in size, with a speed of 10 million instructions per second, costing $.04 per logical unit become available (factor of 2 with 1980).

Micromemories:
Catch up to microprocessors in speed and capacity; inexpensive electric memory devices (using techniques like Josephson Junction) as fast as fastest RAM chips with capacities large enough for mass data storage become available.

Biochips:
Chips produced by bacteria make possible the molecular computer, the molecular switch, organic memory devices; computers become much smaller, faster and cheaper.

Fifth Generation Computers:
Emphasize logic, not just power; can hear, talk, develop knowledge; have active memory that incorporates parallel processing; are used on widespread basis.

Artificially Intelligent Expert Machines:
Knowledge-based system capable of bringing specialized knowledge to bear on non-numerical problems (e.g., medical diagnosis, problem solving) become available and are used widely in the home and in business.

Self-Programming Computers:
Computers that can program themselves become available and are used on a widespread basis.

Universal Programming Language:
A standard is established for programming languages reducing programming costs by 25 percent.

Standardization of Software:
Software packages are standardized so they can be used on all systems; one or several models are established for standardizing data base software.

Terminal/Computer Compatibility:
Standards are adopted by various terminal/computer types making possible the communication among all types of terminals/computers throughout the United States.

Transmission

Direct Broadcast Service:
Widespread use of the direct reception of video or audio signals from satellites to individual receiving antennas, by-passing terrestrial transmission and receiving stations.

High-Definition Television:
Widespread use of HDTV which uses a wider bandwidth than conventional TV and gives a higher resolution picture on a large screen.

Voice Store-and-Forward:
Widespread use of this computerized storage-retrieval system for distribution of voice message communication; users dictate messages over the telephone and call in to retrieve them.

Wrist Radio:
Stadium size antennas make possible communications by way of low power wrist radios.

Antenna Material:
Availability of inexpensive light weight antenna.

Satellite Material:

Availability of lighter, less expensive material developed for satellite production.

Fiber Optics:

Connector, capacity and light source (e.g., solid-state injection lasers) improvements made in fiber optics.

Geo-Stationary Platform:

A stationary place in space is developed and provides facilities for tasks ranging from maintaining and servicing to assembling satellites with high power and capacity.

ECONOMIC

Prosperity:

The following occurs - productivity and GNP up, interest rates and unemployment low, and new businesses and markets established.

Recession-Depression:

The following occurs - productivity and GNP down, interest rates and unemployment very high, business failures increase, market shares lost to foreign competition.

Communications Business Shake Down:

Marginal communications business drop out leaving only major corporations, despite pro-competition stance of Government.

Resources:

Battle between resource exploitation and resource conservation ends as need for critical natural resources increases sharply and requires extensive exploration and conservation.

Global Economy:

Domestic-national economies of both developed and developing countries make global economic planning a high priority.

Industries in Space:

The development of products (e.g., semi-conductors) and the providing of services (e.g., earth observation) in space is a multi-billion (dollar) industry.

SOCIAL-POLITICAL

Domestic-International Satellites:

Domestic satellite systems are connected to international networks via inter-satellite links.

Limited Wars:

Limited wars break out in several key corners of the globe (e.g., Middle East).

Orbit Share:

South America demands and obtains its own unique share of the geostationary orbit.

Acceptance of Technology:

Generation raised on computer games and space exploration not only accepts, but welcomes services like electronic mail to the home and the "Office of the Future" at work.

Work at Home:

Workers and management in a work world becoming more service and white-collar oriented spend more time working at home.

Satellite Importation of Workers:

Widespread use of satellites to obtain labor (i.e., the results of labor, like word processing) from other countries.

Self Help:

Decentralized in a world growing more interdependent causes significant increase in local control and self help groups who need many individual networks.

TABLE B-3

PROBABILITY OF OCCURRENCE

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EVENTS - MDFs	YEARS OF OCCURRENCE		
	10% Chance	50/50 Chance	100% Certain
TECHNOLOGY Input			
Touch Input Devices			
Smart Cards			
Voice Recognition			
Hand-held Terminals			
Output			
Non-Impact Printing			
Flat Output Panels			
Processing			
Microprocessor			
Micromemories			
Biochips			
Fifth Generation Computers			
Artif. Intel, Exp. Machines			
Self-Programming Computers			
Universal Programming Language			
Terminal/Computer Compat.			
Standardization of Software			
Transmission			
Direct Broadcast Service			
High Definition Television			
Voice Store-And-Forward			
Wrist Radio			
Antenna Material			
Satellite Material			
Fiber Optics			
Geo-Stationary Platform			

TABLE B-3 (Continued)

EVENTS - MDFs	YEAR OF OCCURRENCE		
	10% Chance	50/50 Chance	100% Certain
ECONOMIC			
Prosperity			
Recession-Depression			
Communications Business Shake Down			
Resources - Critical Need			
Global Economy			
Industries In Space			
SOCIAL-POLITICAL			
Domestic-International Satellite			
Limited Wars			
Orbit Share			
Acceptance of Technology			
Work at Home			
Satellite Importation of Workers			
Self-Help			
OTHER EVENTS			

LEVEL OF CONFIDENCE: Rating: _______ (1-5; 1 = no basis; 5 = very confident)

Comments: ______________________________

____

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____

TABLE B-4

ESTIMATES OF IMPACTS

(A: 1 = cost, 2 = availability, 3 = ease of use, 4 = need. %: ±N change)

SERVICES / EVENTS - MDFs	VOICE-OVERALL		Message Toll - Residential		Message Toll - Business		Private Line - Telephone		Mobil Radio		Public Radio		Commercial/Religious Radio		Occasional Radio		CATV Music		Recording Channel	
	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%
TECHNOLOGY																				
Input																				
Touch Input Devices																				
Smart Cards																				
Voice Recognition																				
Hand-held Terminals																				
Output																				
Non-Impact Printing																				
Flat Output Panels																				
Processing																				
Microprocessors																				
Micromemories																				
Biochips																				
5th Generation Computers																				
Artif. Intel. Exp. Mach.																				
Self-Programming Compt.																				
Universal Program. Lang																				
Standardization of Soft.																				
Term./Computer Compat.																				
Transmission																				
Direct Broadcast Service																				
High Definition Tele.																				
Voice Store-and-Forward																				
Wrist Radio																				
Antenna Material																				
Satellite Material																				
Fiber Optics																				
Geo-Stationary Platform																				

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TABLE B-4
ESTIMATES OF IMPACTS
(A: 1 = cost, 2 = availability, 3 = ease of use, 4 = need, %: ±N change)

SERVICES / EVENTS - MDFs	VOICE-OVERALL		Message Toll - Residential		Message Toll - Business		Private Line - Telephone		Mobile Radio		Public Radio		Commercial/Religious Radio		Occasional Radio		CATV Music		Recording Channel	
	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%
ECONOMIC																				
Prosperity																				
Recession-Depression																				
Comm. Business Shake Down																				
Resources - Critical Need																				
Global Economy																				
Industries In Space																				
SOCIAL-POLITICAL																				
Domestic-International Sat.																				
Limited Wars																				
Orbit Share																				
Acceptance of Technology																				
Work at Home																				
Sat. Importation of Workers																				
Self Help																				
OTHER EVENTS																				

LEVEL OF CONFIDENCE: Rating _____ (1-5: 1 = no basis, 5 = very confident)

Comments ______________________________
____
____
____

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TABLE B-4

ESTIMATES OF IMPACTS

(A: 1 = cost, 2 = availability, 3 = ease of use, 4 = need, %: ±N change)

SERVICES / EVENTS - MDFs	DATA - OVERALL		Data Transfer		Batch Processing		Data Entry		Remote Job		InquiryResponse		Time Sharing		USPS EMSS		Mailbox		Administrative Message	
	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%
TECHNOLOGY																				
Input																				
Touch Input Devices																				
Smart Cards																				
Voice Recognition																				
Hand-held Terminals																				
Output																				
Non-Impact Printing																				
Flat Output Panels																				
Processing																				
Microprocessors																				
Micromemories																				
Biochips																				
5th Generation Computers																				
Artif. Intel. Exp. Mach.																				
Self-Programming Compt.																				
Universal Program. Lang.																				
Standardization of Soft.																				
Term./Computer Compat.																				
Transmission																				
Direct Broadcast Service																				
High Definition Tele.																				
Voice Store-and-Forward																				
Wrist Radio																				
Antenna Material																				
Satellite Material																				
Fiber Optics																				
Geo-Stationary Platform																				

TABLE B-4

ESTIMATES OF IMPACTS

(A: 1 = cost, 2 = availability, 3 = ease of use, 4 = need, %: +N change)

SERVICES / EVENTS - MDFs	DATA - OVERALL		Data Transfer		Batch Processing		Data Entry		Remote Job		Inquiry/Response		Timesharing		USPS EMSS		Mailbox		Administrative Message	
	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%
ECONOMIC																				
Prosperity																				
Recession-Depression																				
Comm. Business Shake Down																				
Resources - Critical Need																				
Global Economy																				
Industries In Space																				
SOCIAL-POLITICAL																				
Domestic-International Sat.																				
Limited Wars																				
Orbit Share																				
Acceptance of Technology																				
Work at Home																				
Sat. Importation of Workers																				
Self Help																				
OTHER EVENTS																				

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TABLE B-4
ESTIMATES OF IMPACTS
(A: 1 = cost, 2 = availability, 3 = ease of use, 4 = need. %: ±N change)

SERVICES / EVENTS - MDFs	Facsimile		Communicating Word Processor		TWX/Telex		Mailgram/Telegram/ Money Order		Point of Sale		Videotext		Telemonitoring		Secure Voice					
	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%
TECHNOLOGY																				
Input																				
Touch Input Devices																				
Smart Cards																				
Voice Recognition																				
Hand-held Terminals																				
Output																				
Non-Impact Printing																				
Flat Output Panels																				
Processing																				
Microprocessors																				
Micromemories																				
Biochips																				
5th Generation Computers																				
Artif. Intel. Exp. Mach.																				
Self-Programming Compt.																				
Universal Program. Lang.																				
Standardization of Soft.																				
Term./Computer Compat.																				
Transmission																				
Direct Broadcast Service																				
High Definition Tele.																				
Voice Store-and-Forward																				
Wrist Radio																				
Antenna Material																				
Satellite Material																				
Fiber Optics																				
Geo-Stationary Platform																				

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TABLE B-4

ESTIMATES OF IMPACTS

(A: 1 = cost, 2 = availability, 3 = ease of use, 4 = need, %: ±% change)

SERVICES / EVENTS - MDFs	Facsimile		Communicating Word Processor		TWX/Telex		Mailgram/Telegram/ Money Order		Point of Sale		Videotext		Telemonitoring		Secure Voice					
	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%
ECONOMIC																				
Prosperity																				
Recession-Depression																				
Comm. Business Shake Down																				
Resources - Critical Need																				
Global Economy																				
Industries In Space																				
SOCIAL-POLITICAL																				
Domestic-International Sat.																				
Limited Wars																				
Orbit Share																				
Acceptance of Technology																				
Work at Home																				
Sat. Importation of Workers																				
Self Help																				
OTHER EVENTS																				

LEVEL OF CONFIDENCE: Rating ____ (1-5; 1 = no basis, 5 = very confident)

Comments ______________________________

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TABLE B-4

ESTIMATES OF IMPACTS

(A: 1 = cost, 2 = availability, 3 = ease of use, 4 = need, %: ±% change)

SERVICES / EVENTS - MDFs	VIDEO - OVERALL		Network Video		CATV Video		Occasional Video		Recording Channel		Teleconferencing									
	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%
TECHNOLOGY																				
Input																				
Touch Input Devices																				
Smart Cards																				
Voice Recognition																				
Hand-held Terminals																				
Output																				
Non-Impact Printing																				
Flat Output Panels																				
Processing																				
Microprocessors																				
Micromemories																				
Biochips																				
5th Generation Computers																				
Artif. Intel. Exp. Mach.																				
Self-Programming Compt.																				
Universal Program. Lang.																				
Standardization of Soft.																				
Term./Computer Compat.																				
Transmission																				
Direct Broadcast Service																				
High Definition Tele.																				
Voice Store-and-Forward																				
Wrist Radio																				
Antenna Material																				
Satellite Material																				
Fiber Optics																				
Geo-Stationary Platform																				

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TABLE B-4

ESTIMATES OF IMPACTS

(A: 1 = cost, 2 = availability, 3 = ease of use, 4 = need, %: ±N change)

SERVICES / EVENTS - MDFs	VIDEO - OVERALL		Network Video		CATV Video		Occasional Video		Recording Channel		Teleconferencing									
	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%	A	%
ECONOMIC																				
Prosperity																				
Recession-Depression																				
Comm. Business Shake Down																				
Resources - Critical Need																				
Global Economy																				
Industries In Space																				
SOCIAL-POLITICAL																				
Domestic-International Sat.																				
Limited Wars																				
Orbit Share																				
Acceptance of Technology																				
Work at Home																				
Sat. Importation of Workers																				
Self Help																				
OTHER EVENTS																				

LEVEL OF CONFIDENCE: Rating _____ (1-5; 1 = no basis, 5 = very confident)

Comments ____________________

TABLE B-5, EVENT CROSS IMPACTS

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MDFs

1 2 3 4 5,.................33 34 35 36

Touch Input Devices	1
Smart Cards	2
Voice Recognition	3
Hand-Held Terminals	4
Non-Impact Printing	5
Flat Output Panels	6
Microprocessor	7
Micromemories	8
Biochips	9
Fifth Generation Computers	10
Artif. Intel, Exp. Machines	11
Self-Programming Computers	12
Universal Programming Language	13
Terminal/Computer Compatibility	14
Standardization of Software	15
Direct Broadcast Service	16
High Definition Television	17
Voice Store-and-Forward	18
Wrist Radio	19
Antenna Material	20
Satellite Material	21
Fiber Optics	22
Geo-Stationary Platform	23
Prosperity	24
Recession-Depression	25
Communications Business Shake Down	26
Resources - Critical Need	27
Global Economy	28
Industries in Space	29
Domestic-International Satellite	30
Limited Wars	31
Orbit Share	32
Acceptance of Technology	33
Work at Home	34
Satellite Importation of Workers	35
Self-Help	36

IMPACT SCALE

	R	I
Very Strongly Enhancing	3	2
Strongly Enhancing	2	1 2/3
Enhancing	1	1 1/3
Nil	0	1
Inhibiting	-1	2/3
Strongly Inhibiting	-2	1/3
Very Strongly Inhibiting	-3	0

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TABLE B-6

MEAN YEAR OF OCCURENCE FOR MDF'S

MDF'S	PROBABILITY OF OCCURENCE 10 PCT	50 PCT	100 PCT
1 TOUCH INPUT DEVICES	1985	1990	1994
2 SMART CARDS	1986	1990	1993
3 VOICE RECOGNITION	1987	1994	1999
4 HAND HELD TERMINALS	1984	1989	1993
5 NON-IMPACT PRINTING	1985	1991	1996
6 FLAT OUTPUT PANELS	1987	1992	1998
7 MICROPROCESSOR	1983	1985	1988
8 MICROMEMORIES	1984	1987	1990
9 BIOCHIPS	1994	2001	2009
10 FIFTH GENERATION COMPUTERS	1989	1994	2000
11 ARTIF INTEL, EXP MACHINES	1989	1995	2004
12 SELF-PROGRAMMING COMPUTERS	1990	1996	2003
13 UNIVERSAL PROGRAMMING LANGUAGE	1989	1991	1996
14 TERMINAL/COMPUTER COMPATABILITY	1985	1988	1992
15 STANDARDIZATION OF SOFTWARE	1987	1992	1996
16 DIRECT BROADCAST SERVICE	1985	1989	1993
17 HIGH DEFINITION TELEVISION	1988	1990	1994
18 VOICE STORE AND FORWARD	1984	1987	1991
19 WRIST RADIO	1989	1994	2000
20 ANTENNA MATERIAL	1987	1990	1993
21 SATELLITE MATERIAL	1988	1993	1998
22 FIBER OPTICS	1985	1988	1994
23 GEO-STATIONARY PLATFORM	1994	2003	2004
24 PROSPERITY	1985	1988	1993
25 RECESSION/DEPRESSION	1983	1986	1989
26 COMUNICATIONS BUSINESS SHAKE DOWN	1988	1989	1991
27 RESOURCES - CRITICAL NEED	1986	1988	1993
28 GLOBAL ECONOMY	1991	1996	2005
29 INDUSTRIES IN SPACE	1993	2000	2005
30 DOMESTIC INTERNATIONAL SATELLITE	1989	1994	1999
31 LIMITED WARS	1982	1984	1986
32 ORBIT SHARE	1984	1987	1994
33 ACCEPTANCE OF TECHNOLOGY	1985	1990	1994
34 WORK AT HOME	1988	1996	2001
35 SATELLITE IMPORTATION OF WORKERS	1992	1998	2005
36 SELF-HELP	1987	1993	1996

TABLE B-7

NORMALIZED PROBABILITY OF OCCURENCE FOR MDF'S FOR EACH YEAR

MDF'S	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
											YEARS										
TOUCH INPUT DEVICES					0.2	0.9	1.6	2.3	3.1	3.8	4.5	5.6	6.8	7.9	9.0	9.0	9.0	9.0	9.0	9.0	9.0
SMART CARDS							0.9	1.8	2.7	3.6	4.5	6.1	7.6	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
VOICE RECOGNITION							0.6	1.3	2.1	2.9	3.6	4.4	5.2	6.0	6.7	8.1	9.4	10.7	12.1	13.4	13.4
HAND HELD TERMINALS				0.2	0.8	1.5	2.2	2.8	3.5	4.1	5.2	6.2	7.2	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
NON-IMPACT PRINTING					0.3	1.0	1.6	2.3	3.0	3.6	4.3	4.9	5.9	6.9	7.9	8.9	9.9	9.9	9.9	9.9	9.9
FLAT OUTPUT PANELS							0.2	1.2	2.1	3.0	4.0	4.9	5.8	6.8	7.8	8.8	9.7	10.7	11.7	11.7	11.7
MICROPROCESSOR				0.6	1.9	3.2	4.3	5.4	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
MICROMEMORIES					0.7	1.7	2.7	3.6	4.9	6.1	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
BIOCHIPS														1.0	2.3	3.6	4.9	6.2	7.5	8.8	10.1
FIFTH GENERATION COMPUTER									0.3	1.5	2.7	4.0	5.2	6.4	7.6	8.9	10.1	11.4	12.7	14.0	15.2
ARTIF INTEL, EXP MACHINES									0.5	1.4	2.4	3.3	4.3	5.2	6.2	7.1	7.9	8.7	9.5	10.3	11.1
SELF-PROGRAMMING COMPUTER										0.5	1.6	2.7	3.8	4.9	5.9	7.0	8.1	9.3	10.4	11.6	12.7
UNIVERSAL PROGRAMMING LAN										1.1	3.4	5.6	6.7	7.9	9.0	10.1	11.2	11.2	11.2	11.2	11.2
TERMINAL/COMPUTER COMPATA						0.8	1.9	2.9	4.0	5.0	6.0	7.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
STANDARDIZATION OF SOFTWA							0.2	1.1	2.0	2.9	3.7	4.6	5.5	6.9	8.3	9.6	11.0	11.0	11.0	11.0	11.0
DIRECT BROADCAST SERVICE						0.9	1.7	2.6	3.4	4.3	5.3	6.4	7.4	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
HIGH DEFINITION TELEVISIO									1.0	3.0	4.9	6.2	7.4	8.6	9.9	9.9	9.9	9.9	9.9	9.9	9.9
VOICE STORE AND FORWARD					0.7	1.7	2.7	3.7	4.6	5.6	6.5	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
WRIST RADIO									0.3	1.5	2.7	4.0	5.2	6.4	7.6	8.9	10.1	11.4	12.7	14.0	15.2
ANTENNA MATERIAL								0.9	2.2	3.4	4.7	6.2	7.8	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3
SATELLITE MATERIAL								0.3	1.3	2.3	3.3	4.3	5.4	6.4	7.7	9.0	10.2	11.5	12.8	12.8	12.8
FIBER OPTICS						0.8	2.0	3.1	4.2	4.9	5.6	6.3	7.0	7.7	8.4	8.4	8.4	8.4	8.4	8.4	8.4
GEO-STATIONARY PLATFORM													0.2	1.2	2.2	3.1	4.1	5.0	6.0	6.9	7.9
PROSPERITY						0.8	1.9	3.0	4.1	4.9	5.7	6.6	7.4	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
RECESSION/DEPRESSION				0.7	1.6	2.5	3.4	4.5	5.7	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
COMUNICATIONS BUSINESS SH									0.9	4.4	6.6	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
RESOURCES - CRITICAL NEED							0.8	2.5	4.2	5.0	5.9	6.7	7.6	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
GLOBAL ECONOMY											0.3	1.7	3.0	4.3	5.6	6.9	8.3	9.2	10.1	11.0	11.9
INDUSTRIES IN SPACE													0.9	2.0	3.2	4.4	5.6	6.7	7.9	9.1	10.2
DOMESTIC INTERNATIONAL SA									0.3	1.5	2.6	3.8	5.0	6.2	7.3	8.8	10.3	11.7	13.2	14.7	14.7
LIMITED WARS			0.6	1.8	3.0	4.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
ORBIT SHARE					0.8	1.8	2.9	3.9	4.5	5.1	5.6	6.2	6.7	7.3	7.9	7.9	7.9	7.9	7.9	7.9	7.9
ACCEPTANCE OF TECHNOLOGY					0.2	0.9	1.6	2.3	3.1	3.8	4.5	5.6	6.8	7.9	9.0	9.0	9.0	9.0	9.0	9.0	9.0
WORK AT HOME							0.0	0.8	1.6	2.3	3.1	3.9	4.7	5.5	6.3	7.0	7.8	9.4	11.0	12.5	14.1
SATELLITE IMPORTATION OF												0.6	1.9	3.2	4.5	5.8	7.0	8.3	9.6	11.0	12.3
SELF-HELP							0.4	1.2	1.9	2.7	3.5	4.2	5.0	5.8	7.7	9.7	11.6	11.6	11.6	11.6	11.6

TABLE B-8

EVENT CROSS IMPACT RATINGS

MDF'S

MDF'S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1 TOUCH INPUT DEVICES	-3	-1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1
2 SMART CARDS	-1	-3	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
3 VOICE RECOGNITION	-2	0	-3	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0
4 HAND HELD TERMINALS	1	1	0	-3	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
5 NON-IMPACT PRINTING	0	0	0	0	-3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
6 FLAT OUTPUT PANELS	0	0	0	0	1	-3	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 MICROPROCESSOR	0	3	0	3	1	1	-3	2	1	2	2	2	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
8 MICROMEMORIES	0	3	0	3	1	1	2	-3	1	2	2	2	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
9 BIOCHIPS·	0	2	1	1	0	0	2	2	-3	2	2	2	1	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
10 FIFTH GENERATION CO	0	2	1	1	0	0	1	1	1	-3	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
11 ARTIF INTEL, EXP MA	0	2	1	1	0	0	1	1	1	1	-3	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
12 SELF-PROGRAMMING CO	0	2	1	1	0	0	1	1	1	1	1	-3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
13 UNIVERSAL PROGRAMMI	0	1	0	1	0	0	0	0	0	0	0	0	-3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
14 TERMINAL/COMPUTER C	0	1	0	1	0	0	0	0	0	0	0	0	0	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
15 STANDARDIZATION OF	0	1	0	1	0	0	0	0	0	0	0	0	1	1	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
16 DIRECT BROADCAST SE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
17 HIGH DEFINITION TEL	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	-3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
18 VOICE STORE AND FOR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
19 WRIST RADIO	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
20 ANTENNA MATERIAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	-3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
21 SATELLITE MATERIAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	-3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
22 FIBER OPTICS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 GEO-STATIONARY PLAT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	-3	0	0	0	0	0	0	0	0	0	0	0	0	0
24 PROSPERITY	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	-3	-3	-2	1	1	1	1	-1	2	1	1	-1	1
25 RECESSION/DEPRESSIO	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-3	-3	2	-1	-1	-1	-1	1	-1	2	1	-2	2
26 COMUNICATIONS BUSIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3	0	-1	0	0	0	0	-1	-1	0	0
27 RESOURCES - CRITICA	-1	0	-1	0	-1	-1	0	0	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1	-2	2	1	-3	2	2	1	2	2	1	0	0	0
28 GLOBAL ECONOMY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	-1	-1	-3	2	2	-1	-1	1	0	2	0
29 INDUSTRIES IN SPACE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	-1	0	-1	1	-3	1	-1	1	1	0	0	0
30 DOMESTIC INTERNATIO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	1	0	0	0	0	0	1	-3	-1	1	0	0	0	0
31 LIMITED WARS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	-1	-1	-3	-1	-1	0	0	0
32 ORBIT SHARE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	-3	0	0	0	0
33 ACCEPTANCE OF TECHN	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	-1	-1	2	1	1	1	0	1	-3	1	0	0
34 WORK AT HOME	1	0	0	1	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	-3	0	0
35 SATELLITE IMPORTATI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	-3	0
36 SELF-HELP	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	-3

TABLE B-9

MODIFIED NORMALIZED PROBABILITY OF OCCURENCE FOR MDF'S FOR EACH YEAR

MDF'S	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
											YEARS										
TOUCH INPUT DEVICES					0.2	1.0	1.7	2.4	2.9	3.4	3.9	4.6	5.5	7.2	9.6	9.6	9.6	9.6	9.6	9.6	9.6
SMART CARDS							1.1	2.8	4.6	6.4	7.9	9.1	9.1	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
VOICE RECOGNITION							0.5	1.2	2.0	2.7	3.5	4.3	5.1	5.9	6.6	7.7	8.7	9.5	10.2	10.7	10.7
HAND HELD TERMINALS				0.1	1.0	2.1	3.5	4.8	6.1	7.2	8.3	8.3	8.2	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
NON-IMPACT PRINTING					0.3	0.9	1.6	2.4	3.1	3.8	4.5	5.2	6.1	6.8	7.5	8.0	8.4	8.4	8.4	8.4	8.4
FLAT OUTPUT PANELS							0.2	1.0	2.0	3.0	4.0	5.0	5.9	6.8	7.5	8.1	8.6	8.9	9.1	9.1	9.1
MICROPROCESSOR				0.8	2.8	4.8	5.9	6.4	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
MICROMEMORIES					0.8	2.3	3.8	5.2	6.4	7.0	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
BIOCHIPS														0.4	0.9	1.5	2.2	2.9	3.6	4.2	4.9
FIFTH GENERATION COMPUTER									0.2	1.1	2.3	3.5	4.9	6.2	7.3	8.3	9.0	9.4	9.4	9.0	8.1
ARTIF INTEL, EXP MACHINES									0.2	0.8	1.5	2.3	3.1	3.9	4.6	5.3	5.8	6.2	6.5	6.7	6.8
SELF-PROGRAMMING COMPUTER										0.3	0.9	1.7	2.6	3.5	4.5	5.3	6.1	6.8	7.4	7.7	7.9
UNIVERSAL PROGRAMMING LAN										1.1	3.6	6.0	7.1	8.1	8.9	9.6	10.1	10.1	10.1	10.1	10.1
TERMINAL/COMPUTER COMPATA						0.9	2.4	4.0	5.5	6.5	7.2	7.3	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
STANDARDIZATION OF SOFTWA							0.2	1.1	2.0	2.9	3.8	4.7	5.6	7.0	8.3	9.5	10.5	10.5	10.5	10.5	10.5
DIRECT BROADCAST SERVICE						0.8	1.8	2.8	3.8	4.8	5.8	6.6	7.2	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
HIGH DEFINITION TELEVISIO									1.0	3.4	5.8	7.1	7.9	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
VOICE STORE AND FORWARD					0.8	1.8	2.9	4.0	4.9	5.7	6.5	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
WRIST RADIO									0.2	1.1	2.3	3.6	4.9	6.3	7.4	8.4	9.2	9.5	9.4	8.9	7.9
ANTENNA MATERIAL								0.9	2.5	4.1	5.6	7.1	8.0	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
SATELLITE MATERIAL								0.2	1.1	2.1	3.2	4.4	5.5	6.5	7.6	8.5	9.1	9.4	9.3	9.3	9.3
FIBER OPTICS						0.8	2.1	3.3	4.5	5.1	5.7	6.3	6.8	7.3	7.8	7.8	7.8	7.8	7.8	7.8	7.8
GEO-STATIONARY PLATFORM													0.1	0.4	0.7	1.1	1.5	2.0	2.4	2.8	3.3
PROSPERITY						1.3	2.6	3.2	3.2	2.8	2.0	1.1	0.2	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
RECESSION/DEPRESSION				0.8	1.5	1.9	1.9	1.4	0.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
COMUNICATIONS BUSINESS SH									0.9	3.5	5.0	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
RESOURCES - CRITICAL NEED							0.9	2.6	4.2	4.9	5.7	6.5	7.4	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
GLOBAL ECONOMY											0.2	1.1	2.1	3.1	4.0	5.0	5.8	6.4	6.9	7.4	7.9
INDUSTRIES IN SPACE													0.4	0.9	1.5	2.2	2.8	3.5	4.1	4.8	5.3
DOMESTIC INTERNATIONAL SA									0.2	1.3	2.5	3.8	5.0	6.2	7.3	8.6	9.6	10.6	11.4	12.1	12.1
LIMITED WARS			0.6	1.7	2.7	3.9	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
ORBIT SHARE					0.8	2.0	3.2	4.3	4.8	5.2	5.6	6.0	6.4	6.8	7.3	7.3	7.3	7.3	7.3	7.3	7.3
ACCEPTANCE OF TECHNOLOGY					0.1	0.9	1.9	2.9	4.0	5.0	6.0	7.1	7.7	7.7	7.0	7.0	7.0	7.0	7.0	7.0	7.0
WORK AT HOME							0.0	0.4	0.9	1.5	2.2	3.0	3.7	4.5	5.2	5.9	6.6	7.5	8.0	7.9	7.1
SATELLITE IMPORTATION OF												0.4	1.3	2.1	2.9	3.6	4.4	5.0	5.6	6.2	6.8
SELF-HELP							0.3	1.1	2.0	3.0	4.1	5.1	6.1	7.0	8.8	9.5	8.7	8.7	8.7	8.7	8.7

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE B-10

EVENT IMPACTS ON SERVICES

SERVICES

MDF'S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1 TOUCH INPUT DEVICES	1	1	0	0	0	0	0	0	1	0	0	5	3	3	0	1	0	1	0	2	0	2	2	5	0	0	0	0	0	2	2
2 SMART CARDS	0	0	0	0	0	0	0	0	1	0	0	3	2	2	0	3	1	1	0	0	0	1	10	3	0	3	0	3	0	2	0
3 VOICE RECOGNITION	0	0	0	0	0	0	0	0	0	0	0	3	3	3	0	0	1	3	0	8	0	1	1	2	1	1	0	0	0	0	1
4 HAND HELD TERMINALS	1	1	0	1	0	0	0	0	1	0	0	2	1	3	0	2	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0
5 NON-IMPACT PRINTING	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
6 FLAT OUTPUT PANELS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
7 MICROPROCESSOR	2	2	1	1	0	0	0	0	1	2	2	1	1	1	1	1	1	1	0	1	0	0	1	2	1	1	0	1	2	2	3
8 MICROMEMORIES	0	0	0	0	0	0	1	2	2	1	3	1	1	2	0	1	1	1	2	1	0	2	1	2	1	1	0	1	2	2	3
9 BIOCHIPS	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1	1	0	1	0	0	1	1	1	1	0	1	2	2	3
10 FIFTH GENERATION COMPUTERS	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 ARTIF INTEL, EXP MACHINES	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
12 SELF-PROGRAMMING COMPUTERS	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
13 UNIVERSAL PROGRAMMING LANGUAGE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 TERMINAL/COMPUTER COMPATABILIT	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
15 STANDARDIZATION OF SOFTWARE	0	0	0	1	0	0	0	0	0	2	0	0	2	2	0	0	0	0	0	3	0	0	2	2	0	0	0	0	0	0	0
16 DIRECT BROADCAST SERVICE	0	0	0	0	¯1	¯1	¯1	¯1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	¯1	¯2	¯2	5	0
17 HIGH DEFINITION TELEVISION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	2	3	0
18 VOICE STORE AND FORWARD	¯1	¯1	0	0	0	0	0	0	0	0	0	0	0	0	0	¯2	¯2	¯2	0	0	0	¯1	0	0	0	0	0	0	0	0	0
19 WRIST RADIO	1	1	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	2	2	2	2
20 ANTENNA MATERIAL	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2
21 SATELLITE MATERIAL	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	2	2
22 FIBER OPTICS	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 GEO-STATIONARY PLATFORM	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
24 PROSPERITY	2	2	2	4	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	2	0	1	3	2	1	1	0	3	2	3	5
25 RECESSION/DEPRESSION	¯1	¯1	¯1	¯2	¯1	¯1	¯1	¯1	¯1	¯1	¯1	¯1	¯1	¯1	¯1	¯1	¯1	¯1	¯1	¯1	0	¯1	¯2	¯1	¯1	¯1	0	¯1	¯1	¯1	¯5
26 COMUNICATIONS BUSINESS SHAKE D	1	1	0	0	0	0	0	0	0	0	0	0	0	0	¯1	0	0	0	0	0	0	0	1	0	0	0	0	¯1	0	0	0
27 RESOURCES - CRITICAL NEED	¯1	¯1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	¯2	0	0	0	0	0	0	3
28 GLOBAL ECONOMY	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1
29 INDUSTRIES IN SPACE	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	2	3	5
30 DOMESTIC INTERNATIONAL SATELLI	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	1	1	1	1
31 LIMITED WARS	¯1	¯1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
32 ORBIT SHARE	¯1	¯1	¯1	¯1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	¯1	¯1	¯1	¯1	¯1
33 ACCEPTANCE OF TECHNOLOGY	0	0	0	3	0	0	0	1	2	0	0	0	0	0	5	3	3	2	0	5	0	5	5	5	0	0	0	2	1	2	5
34 WORK AT HOME	2	2	0	0	0	0	0	0	0	1	0	0	3	0	1	1	1	2	0	0	0	0	0	1	0	0	0	0	0	0	2
35 SATELLITE IMPORTATION OF WORKE	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1
36 SELF-HELP	2	0	0	0	0	0	2	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

TABLE B-11
IMPACTED BASELINE FORECAST FOR EACH SERVICE FOR EACH YEAR

SERVICE	YEAR 1980	YEAR 1990	YEAR 2000
VOICE (1000s HVCs)			
MTS (RESIDENTIAL)	593.0	1319.2	2896.7
MTS (BUSINESS)	1588.0	4215.0	9702.4
PRIVATE LINE	644.4	2649.4	7147.7
MOBILE	1.4	36.7	117.6
PUBLIC RADIO	0.3	1.8	2.6
COMMERCIAL AND RELIGIOUS	0.5	2.0	3.2
OCCASIONAL	1.2	2.4	3.7
CATV MUSIC	0.1	0.3	1.2
RECORDING	0.0	0.0	0.9
TOTAL	2828.9	8226.8	19875.9
DATA (TERABITS/YR)			
DATA TRANSFER	464.0	1460.8	6844.5
BATCH PROCESSING	304.0	951.8	1755.6
DATA ENTRY	380.0	2167.6	8715.4
REMOTE JOB ENTRY	165.0	1413.6	2825.2
INQUIRY/RESPONSE	165.0	1462.9	3842.5
TIMESHARING	94.0	277.2	545.6
USPS/EMSS	0.0	361.7	1084.2
MAILBOX	0.2	5.1	13.5
ADMINISTRATIVE MESSAGES	48.5	316.0	1025.1
FACSIMILE	235.5	549.4	1253.0
COMMUNICATING WORD PROCE	17.1	131.2	519.3
TWX/TELEX	1.2	1.6	2.2
MAILGRAM/TELEGRAM/MONEY	0.4	0.9	1.8
POINT OF SALE	12.0	254.3	468.4
VIDEOTEXT/TELETEXT	0.1	321.7	1258.3
TELEMONITORING SERVICE	0.1	0.8	3.6
SECURE VOICE	5.3	163.3	944.4
TOTAL	1892.3	9839.9	31102.6
VIDEO (TRANSPONDERS)			
NETWORK	10.0	42.9	42.0
CATV	34.0	82.4	68.2
OCCASIONAL	19.0	55.4	47.9
RECORDING CHANNEL	0.0	0.0	2.7
TELECONFERENCING	3.0	155.9	245.3
TOTAL	66.0	336.7	406.0

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TABLE B-12
PERCENT DIFFERENCE BETWEEN BASELINE AND IMPACTED BASELINE FORECASTS

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (RESIDENTIAL)	0.0	3.1	9.8
MTS (BUSINESS)	0.0	2.4	9.1
PRIVATE LINE	0.0	1.6	5.7
MOBILE	0.0	5.2	14.0
PUBLIC RADIO	0.0	(1.5)	(0.9)
COMMERCIAL AND RELIGIOUS	0.0	(1.5)	(0.9)
OCCASIONAL	0.0	0.2	1.7
CATV MUSIC	0.0	1.0	1.8
RECORDING	0.0	0.0	8.6
TOTAL	0.0	2.3	8.0
DATA			
DATA TRANSFER	0.0	4.3	9.7
BATCH PROCESSING	0.0	4.4	7.0
DATA ENTRY	0.0	10.6	19.1
REMOTE JOB ENTRY	0.0	9.2	21.8
INQUIRY/RESPONSE	0.0	13.0	24.4
TIMESHARING	0.0	3.4	4.9
USPS/EMSS	0.0	6.9	8.8
MAILBOX	0.0	3.9	6.0
ADMINISTRATIVE MESSAGES	0.0	5.3	9.9
FACSIMILE	0.0	1.0	1.9
COMMUNICATING WORD PROCE	0.0	12.1	29.7
TWX/TELEX	0.0	0.0	0.0
MAILGRAM/TELEGRAM/MONEY	0.0	7.1	10.4
POINT OF SALE	0.0	18.6	30.1
VIDEOTEXT/TELETEXT	0.0	17.0	37.2
TELEMONITORING SERVICE	0.0	1.4	3.0
SECURE VOICE	0.0	4.0	5.6
TOTAL	0.0	8.3	15.7
VIDEO			
NETWORK	0.0	2.2	4.9
CATV	0.0	8.4	19.6
OCCASIONAL	0.0	6.6	16.9
RECORDING CHANNEL	0.0	0.0	32.6
TELECONFERENCING	0.0	12.2	42.6
TOTAL	0.0	9.0	30.1

APPENDIX C
MARKET DISTRIBUTION MODEL

The market distribution model (MDM) is a set of internal programs (see Figure C-1) used to facilitate the interface between market research and the quantitative results which are needed to support market planning. It uses 64 data bases (as given below in Table C-1) along with algorithms relating size and distance to determine the attractiveness between standard metropolitan statistical areas (SMSAs). This relationship was developed for each of the 31 services in the baseline forecast (using the percentages given in Table C-2) based on primary and secondary research as to the relationship of the data bases to the services. This allowed the traffic to be spread throughout the United States to the various SMSAs. The steps below explain in more detail the use of MDM.

1. Determine the desired geographic/market segment to be addressed.
2. Select a set of data bases from within the MDM which reflect the service's characteristics.
3. Develop weighting factors for each selected data base. The weighting factor represents a statistical measure which assigns a relative value to each data base to reflect their individual importance.
4. The computerized model is then utilized to record assumptions for the weighting factors, statistically validate applicability of data base selection to form a weighted sum of the data bases (all of which have been converted to percentages), and then use the distance sensitivity measure as an input to an algorithm which converts the total static data base to a dynamic (flow) one.
5. This newly formed dynamic data base is combined in a weighted fashion with the previously selected dynamic data bases to create a final SMSA paired service which contains a relative value measuring communication potential between all selected SMSA's.
6. This result is normalized so that the total of all individual route values between SMSA's sums to 100%.
7. The data file can now be used to examine the relative demand potential between SMSA pairs.

A unique aspect of this model is the creation of "artificial SMSAs." An artificial SMSA is created to represent that area of a state located outside of the designated SMSA. The statistics for this area are created by subtracting the designated SMSA statistics from the state statistics. For instance, population of an artificial SMSA is: State population - State Designated SMSAs. More detail on the creation and use of artificial SMSAs is given in the Net Long Haul Appendix.

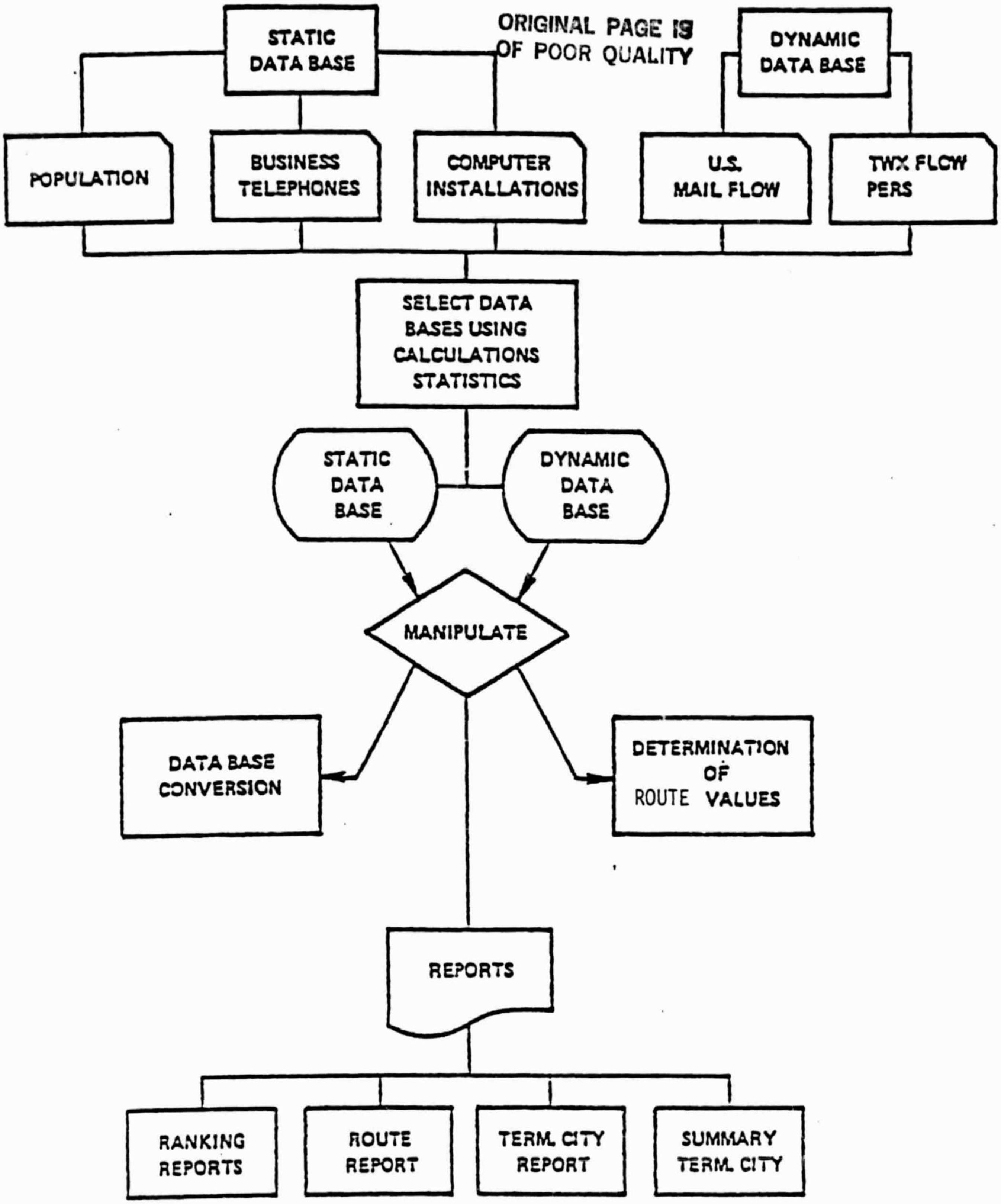

FIGURE C-1. MARKET DISTRIBUTION MODEL

TABLE C-1. FILES USED WITH MDM

	FILE NAME	SMSA SOURCE	STATE SOURCE
1.	SMSA Number		
2.	SMSA Name	Commerce	
3.	Regional Name	Commerce	
4.	SCSA Numbers	Commerce	
5.	Time Zones	Rand McNally	
6.	Artificial V&H Coordinates	Standard Table	
7.	State Capital		
8.	Land Area		Almanac
9.	Population	1980 Census	1980 Census
10.	Projected 1990 population in thousands and % change 1980 to 1990	Census of Governments	1981 Rand McNally (R/M)
11.	Number of locations over 100,000		R/M
12.	Number of locations over 50,000		R/M
13.	Number of locations over 25,000		R/M
14.	Number of locations over 10,000		R/M
15.	Number of locations over 5,000		R/M
16.	Number of locations over 2,500		R/M
17.	Number of locations over 1,000		R/M
18.	1979 Per Household Income (top 100, whole dollars)	Marketing Economics Institute	R/M
19.	Personal Income		
	1978	Bureau of Economic Affairs 1980 (B.E.A.)	
	1990	B.E.A.	
	2000	B.E.A.	
20.	Employment (Non Farm)		
	1978	B.E.A.	
	1990	B.E.A.	
	2000	B.E.A.	

TABLE C-1. FILES USED WITH MDM (Continued)

	FILE NAME	SMSA SOURCE	STATE SOURCE
21.	Transportation, Communications and Public Utilities Employment		
	1978	B.E.A.	
	1990	B.E.A.	
	2000	B.E.A.	
22.	Retail Trade Employment		
	1978	B.E.A.	
	1990	B.E.A.	
	2000	B.E.A.	
23.	Finance, Insurance and Real Estate Employment		
	1978	B.E.A.	
	1990	B.E.A.	
	2000	B.E.A.	
24.	Service Employment		
	1978	B.E.A.	
	1990	B.E.A.	
	2000	B.E.A.	
25.	Population		
	1978	B.E.A.	
	1990	B.E.A.	
	2000	B.E.A.	
26.	Number of Residential Telephones	FCC Common Carrier Statistics	FCC Stats 1980
27.	Number of One-Way CATV Households	Television Fact-Book 1980	Television Fact-Book 1980
28.	Number of Two-Way CATV Households	Television Fact-Book 1980	Television Fact-Book 1980
29.	College Population	1977 Census of Governments (Census Bureau 1979)	1977 Census of Governments
30.	Number of Business Telephones	FCC Stats 1980	FCC Stats 1980
31.	1977 Number of Hospital Beds (in thousands)	1977 Census (Data Book)	1977 Census (Data Book)

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TABLE C-1. FILES USED WITH MDM (Continued)

	FILE NAME	SMSA SOURCE	STATE SOURCE
32.	Number of Headquarters of Top 1,000 Industrial Corporations	Fortune Double 500 Directory	
33.	Number of Top 50 Commercial Bank Headquarters	R/M	
34.	Number of Top 50 Insurance Company Headquarters	R/M	
35.	Number of Top 50 Retailing Company Headquarters	R/M	
36.	Number of Top 50 Transportation Company Headquarters	R/M	
37.	1977 Total Bank Deposits in Millions of Dollars - June	State/Metropolitan Area Data Book 1979	
38.	Automatic Clearing House Locations and Federal Reserve Locations	Federal Reserve Board 1982	
39.	1978 Retail Sales ($1,000)	Federal Reserve Board 1981	
40.	Value Added by Manufacturing	R/M	
41.	Principal Business Center Interaction (City Rating)	R/M	
42.	TWX Billings	WU - 1978	
43.	TWX Billings Elapsed Time	WU - 1978	
44.	TWX Terminals	WU - 1978	
45.	Telex Terminals	WU - 1978	
46.	Microwave Circuits	WU - 1978	
47.	Prime AT&T Market	WU - 1982	
48.	WU Prime Rate Center	WU - 1982	
49.	Mail Flow	U.S.P.S. - 1977 (Mail Flow)	

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TABLE C-1. FILES USED WITH MDM (Continued)

	FILE NAME	SMSA SOURCE	STATE SOURCE
50.	P.O. Electronics Mail Facilities	1982 - U.S.P.S.	
51.	Number of Main Frames Used in Business, Finance and Insurance	International Data Corporation 1980	
52.	Computer Terminal Locations	1980	
53.	Computer and Data Processing Receipts	1977 Economic Census	
54.	Receipts of Management, Consulting and P.R. Services Industries (in millions of dollars)	1977 Economic Census	
55.	Manufacturing Industry Employment	1977 Census of Whole-Trade	
56.	EBI - Economic Business Indicator	Sales and Marketing Management Magazine	
57.	Number of Earth Stations	Satellite Review Book	
58.	1977 Local Full-Time Government Employees	1977 Census of Governments	
59.	Full-Time State/Local Employees (in thousands)		1977 Census of Government
60.	1976 Total Federal Employees (as of December) 1978 1990 2000	Commerce 1977 Census of Governments	1977 Census of Governments
61.	Total Military Employees 1978 1990 2000	Commerce 1977 Census of Governments	1977 Census of Governments
62.	Federal Government Data Processing Inventory	General Services Administration	
63.	Federal Government Workers in Data Processing	General Services Administration	
64.	WESTAR Services	WU - 1977	

TABLE C-2. PERCENTAGES (WEIGHTINGS) USED TO REFLECT DATA BASE AND SERVICE RELATIONSHIPS

	DATA BASES																			
SERVICES	8	9	26	30	37	60	31	19	21	23	22	50	20	24	61	59	38	52	53	43
MTS (Residential)	20		50					20					10							
MTS (Business)				40	10	10			10	10				10		10				
Private Line				40	15	10				10						10			15	
Mobile		10		50	15					10	10					5				
Public Radio - LD																				
Commercial and Religious - LD																				
Occasional - LD																				
CATV Music - LD																				
Recording - LD																				
Data Transfer		10			20	10				15				10		5	5	15	10	
Batch Processing		10			20	10				15				10		5	5	15	10	
Data Entry		10			20	10				15				10		5	5	15	10	
Remote Job Entry		10			20	10				15				10		5	5	15	10	
Inquiry/Response		10			20	10				15				10		5	5	15	10	
Timesharing		10			20	10				15				10		5	5	15	10	
USPS/EMSS		10		20	20	10				15				10		5	5	5	10	
Mailbox		10		20	20	5		5				15	10			5			10	
Administrative Messages		10		20	20	5		5				15	10			5			10	
Facsimile		10		20	20	5		5				15	10			5			10	
Communicating Word Processors		10		20	20	5		5				15	10			5			10	
TWX/Telex		10		20	20	5		5				15	10			5			10	
Mailgram/Telegram/Money Orders		30		10				10												50
Point of Sale		30		10			10				30		10					10		
Videotext/Teletext	10	10	10	25	20	10				10						5				
Telemonitoring Service		50			10			20					20							
Secure Voice				20			15								60	5				
Network - LD*																				
CATV - LD																				
Occasional - LD																				
Recording Channel - LD																				
Teleconferencing - LD																				

*LD - All radio and video traffic is defined as satellite traffic.

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APPENDIX D
NET LONG HAUL FORECAST

D.1 INTRODUCTION

The impacted baseline was modified by two market constraints to produce the net long haul forecast. These market constraints required the removal of traffic which was intra SMSA in nature (i.e. traffic which flows within a Standard Metropolitan Statistical Areas (SMSA), traffic originated or terminated from the hinterlands (rural area outside of the SMSA) and data carried over voice lines, usually via modems. The percent of traffic removed from each service to get to the net long haul is given in Table D-1. Two other adjustments are made to the traffic at this point; efficiency factors are applied to data traffic and annual traffic is converted to peak hour units. The resulting net long haul traffic forecast shown in Table D-5 was the basis for all traffic distribution and traffic separation analyses which follows. Figure D-1 depicts the basic flow of the analysis necessary to translate the impacted baselines into the net long haul traffic forecasts.

D.2 INTRA SMSA TRAFFIC

A certain proportion of each service application traffic does not leave the SMSA in which it was originated. By definition this traffic does not qualify as long haul and must be removed from the forecasts. Many services already had this portion of the traffic removed, such as Network video. For other services the amount of intra SMSA traffic varied greatly. Therefore, each service was reviewed independently and a percent of traffic was removed (see Table D-1). The percent of intra SMSA traffic was developed through industry contacts, our literature search, the user survey and internal Western Union analysis.

D.2.1 Voice

The voice traffic forecast was analyzed using AT&T statistics as well as the physical boundaries of SMSAs. Message toll service for both residential and business is almost all inter SMSA. The exception is in large SMSAs where some interSMSA traffic is counted as toll. This was found to be small. Private line

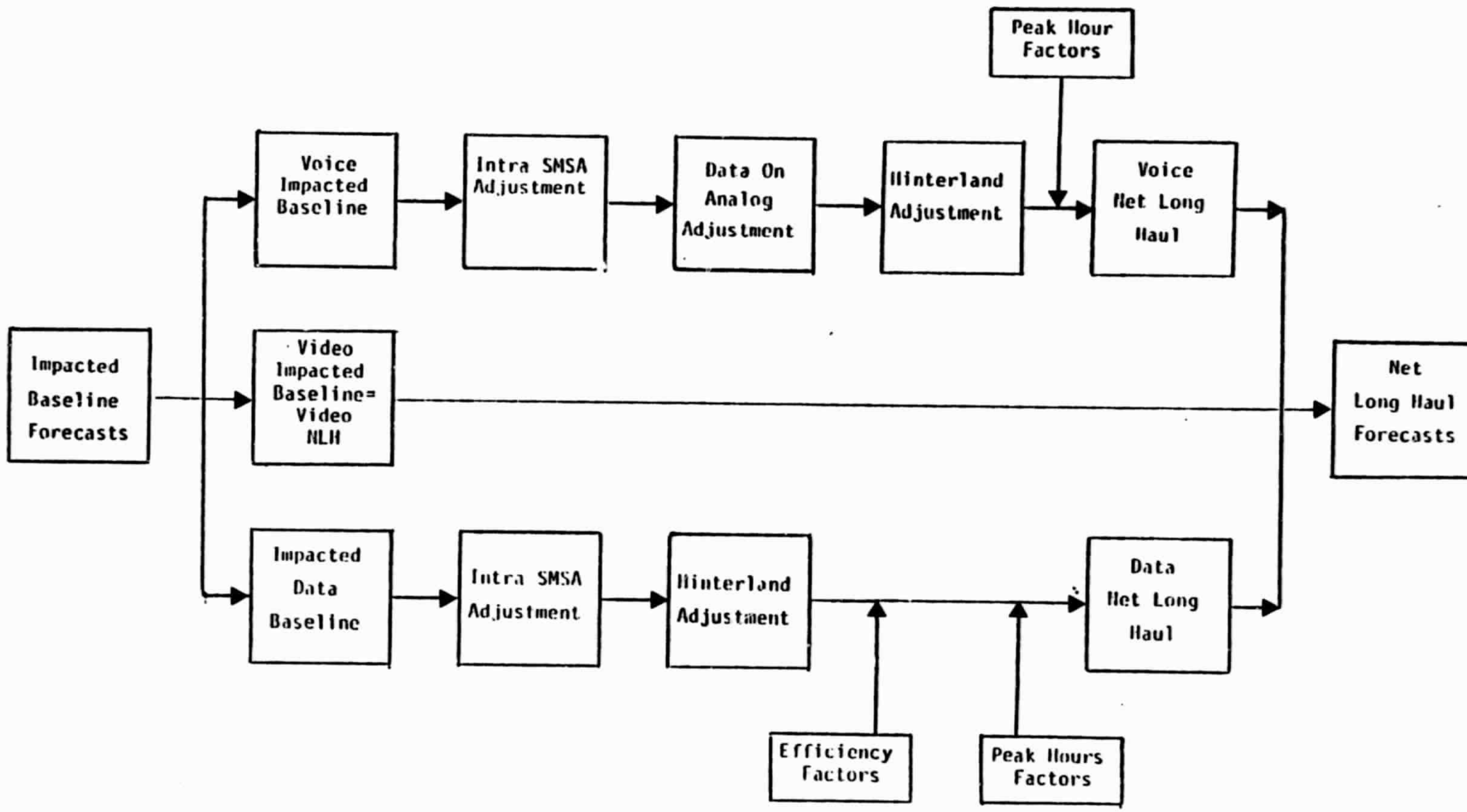

FIGURE D-1. ACTIVITY FLOW FOR NET LONG HAUL FORECASTS

TABLE D-1. PERCENT OF TRAFFIC REMOVED FROM THE IMPACTED BASELINE TO GIVE NET LONG HAUL TRAFFIC FORECAST

SERVICE	INTRA SMSA	DATA CARRIED BY VOICE LINES 1980	1990	2000	HINTERLAND TRAFFIC 1980	1990	2000
VOICE							
MTS (Residential)	9.00	0.00	0.00	0.00	15.53	15.53	15.53
MTS (Business)	5.00	5.29	0.76	0.08	17.04	17.90	18.03
Private Line	5.00	8.69	3.61	1.01	16.00	16.94	17.43
Mobile	5.00	0.00	0.00	0.00	17.26	17.26	17.26
Public Radio	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commercial and Religious	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Occasional	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CATV Music	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Recording	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	5.83	4.95	1.55	0.40	16.48	17.20	17.43
DATA							
Data Transfer	16.00	0.00	0.00	0.00	17.57	17.57	17.57
Batch Processing	20.00	0.00	0.00	0.00	16.73	16.73	16.73
Data Entry	60.00	0.00	0.00	0.00	8.37	8.37	8.37
Remote Job Entry	35.00	0.00	0.00	0.00	13.60	13.60	13.60
Inquiry/Response	50.00	0.00	0.00	0.00	10.46	10.46	10.46
Timesharing	30.00	0.00	0.00	0.00	14.64	14.64	14.64
USPS/EMSS	0.00	0.00	0.00	0.00	0.00	17.20	17.20
Mailbox	25.00	0.00	0.00	0.00	14.41	14.41	14.41
Administrative Messages	40.00	0.00	0.00	0.00	11.53	11.53	11.53
Facsimile	10.00	0.00	0.00	0.00	17.30	17.30	17.30
Communicating Word Processors	30.00	0.00	0.00	0.00	13.45	13.45	13.45
TWX/TELEX	1.00	0.00	0.00	0.00	19.99	19.99	19.99
Mailgram/Telegram/Money Orders	2.00	0.00	0.00	0.00	19.22	19.22	19.22
Point of Sale	70.00	0.00	0.00	0.00	6.77	6.77	6.77
Videotext/Teletext	0.00	0.00	0.00	0.00	22.96	22.96	22.96
Telemonitoring Service	75.00	0.00	0.00	0.00	5.85	5.85	5.85
Secure Voice	10.00	0.00	0.00	0.00	18.06	18.06	18.06
TOTAL	31.11	0.00	0.00	0.00	14.18	13.38	13.43
VIDEO							
Network	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CATV	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Occasional	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Recording Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Teleconferencing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	0.00	0.00	0.00	0.00	0.00	0.00

and mobile telephones were treated similarly to message toll services. The various radio services are defined as inter SMSA in the baseline and thus no traffic was removed.

D.2.2 Data

For data an internal analysis prepared by Western Union and International Data Corporation provided information about line speed and the distance traffic travels. Along with this a review of the individual services based on Western Union's own experience was used to estimate the intra SMSA traffic.

D.2.3 Video

The baseline for all video services is defined as long haul and thus an estimate of the intra SMSA traffic is meaningless.

D.3 DATA TRAFFIC CARRIED ON ANALOG (VOICE) FACILITIES

The data service category net long haul traffic forecast has been calculated on the basis of market demand - without consideration of the transmission facilities used. The voice service category has been calculated in a similar manner. However, the voice forecasts, which were based on historical growth patterns, included facilities on which data traffic was implemented. If the forecasts were not modified to acknowledge this situation, a duplication in market demand would be caused.

It was decided that the data service category forecasts should remain whole and that the voice service category should be reduced by the amount of the data traffic carried. This would allow the data market demand to remain intact as an aid to subsequent market analyses.

The methodology used to convert applicable data traffic (expressed in terabits per year) to voice traffic (expressed in half voice circuits) included the following steps:

a. Analyze each data application to determine the nature of the traffic: peak oriented; off-peak oriented; one-way; two-way or special.
b. Derive a conversion factor to convert terabits per year to half voice circuits which takes nature of traffic into account.
c. Calculate equivalent voice facilities load for all data traffic.
d. Analyze each data application to determine the proportion carried on voice facilities in 1978, 1980, 1990 and 2000.
e. Calculate net voice facilities carrying data traffic and reduce voice service category forecasts by a like amount.

Very few dedicated data facilities are currently in use. In 1980, approximately 90 percent of data traffic was carried on voice facilities. Anticipating the amergence of digital facilities, the weighted average of data on voice facilities declined to 67 percent in 1990 and 25 percent in 2000. (See Table D-2). The percent of data carried by voice lines is presented, by service and year, in Table D-1.

D.4 HINTERLAND TRAFFIC

The assumption is made that traffic going to or coming from areas outside of the 316 continental SMSAs will not be routed through a trunking network and therefore should not be included. To determine the percent of traffic this includes artificial SMSAs were created. This was done by gathering the same information on a statewide basis which was gathered on an SMSA basis (see the MDM appendix). It was then possible to subtract these files and thus have data bases for every state covering those areas outside of the SMSAs. The V or H coordinates for the artificial SMSAs were then chosen so the artificial SMSA would be located in the center of the state. Using the market distribution model (MDM) traffic was then routed to each of the real and artificial SMSAs. The artificial routes were then removed. The percentage each service is reduced by is shown in Table D-1.

D.5 PEAK HOUR CONVERSION

The next step in developing the long haul peak hour traffic forecast was to establish a peaking factor for every service. Since voice is a large share of the

TABLE D-2. DATA ON ANALOG

PERCENT OF LONG HAUL DATA TRAFFIC CARRIED ON ANALOG

1980	1990	2000
90	67	25

TYPE OF CIRCUITS DATA TRAFFIC CARRIED

	1980	1990	2000
MTS (BUSINESS)	40	25	10
PRIVATE LINE	60	75	90

AVERAGE BIT RATE OF ANALOG (KBPS)

1980	1990	2000
1.2	4.8	9.6

market and its peak occurs during the business day and most services are business oriented, all peak hours were made to coincide with the 10 to 11 a.m. and the 1 to 3 p.m. business peak time frames.

D.5.1 Voice

The baseline for most voice services is defined as the peak hour traffic and therefore no conversion was necessary. The exception to this is occasional radio which is peaked at nights and weekends. A review of Western Union's WESTAR satellite traffic indicated that the traffic during the business peak hour was 75 percent of the services peak hour.

D.5.2 Data

To determine the amount of data traffic occuring in a business day, it was first necessary to divide all data services by 250 (the number of business days per year). Then each service was reviewed to see what type of daily traffic pattern was followed. The user survey and Western Union's experience provided useful insights. Most data services occur during the day and are fairly constant. Some exceptions are data transfer and batch processing which occur largely after normal hours and secure voice which follows a traffic pattern similar to voice. The number of hours during the work day the service is used and the percentage of the service taking place during those hours was used to determine the amount of traffic in the peak hour. The percent used during the work day is given in column one of Table D-3. The number of hours of constant use is given in the second column. The last column shows the factor applied to get the peak hour for each service. That is, the peak hour factor for each service was calculated by multiplying the percent during the business week (e.g., 25 for data) times 1/250 times 1/(#hours of use/day, e.g., 5 for data)

D.5.3 Video

The baseline for all video services, except occasional video, was defined as peak hour. The occasional video impacted baseline was reduced by 25 percent for each bench mark year to reflect its unique peak hour factor.

TABLE D-3. DATA SERVICE PEAK HOUR CONVERSION

	PERCENT DURING BUSINESS WEEK 8 A.M. to 5 P.M. MONDAY THROUGH FRIDAY	NUMBER OF HOURS OF USE	PEAK HOUR FACTOR
DATA	25	5	.0002
BATCH	50	5	.0004
DATA ENTRY	95	5	.0008
REMOTE	85	5	.0007
INQUIRY/RESPONSE	90	4	.0010
TIME SHARING	90	4	.0010
USPS	80	6	.0005
MAILBOX	90	6	.0006
ADMINISTRATIVE	95	4	.0010
FACSIMILE	98	4	.0007
CWP	80	4	.0005
TWX/TELEX	80	4	.0005
MAILGRAM	80	6	.0005
POINT OF SALE	50	7	.0003
VIDEOTEXT	75	6	.0005
TELEMONITORING	30	10	.0001
SECURE VOICE	90	4	.0010

D.6 EFFICIENCY FACTOR

This term refers to how efficiently data is transmitted. In the case of data the rate of transmission is often less then the channel capacity. For instance the capacity of a voice channel in 1980 was 64 Kbps, however, when a modem was introduced for data the rate of transmission was 300 or 1200 bps. In addition to this when the actual data transmitted by a typist at a keyboard is considered, this rate is reduced considerably. Other factors must also be considered such as pauses made by the typist. Most data must have a return line, thus typing up a second 64 Kbps line and error correction techniques may require retransmission.

All data efficiency factors were determined by considering that all data services were transmitted using one of two methods. First the data could be entered manually through some type of keyboard, for example data entry, point of sale or telemonitoring. This type of transmission would be very inefficient. The second way data is normally transmitted is in a batch mode. For example, data transfer, batch processing and that portion of data entry done using a micro-computer as an input device. This type of data entry still is not totally efficient, however. For instance the return line is underutilized and error correction schemes often call for retransmission. Several other factors were also considered in determining these factors. The use of micro-computers to store and forward data in burst is a growing trend. The use of all digital transmission will mean the elimination of modems and some inefficiency. Compression techniques and the use of higher speeds will increase efficiency. These trends combined to increase the efficiency of the transmission lines in 1990 and 2000. Table D-4 presents the efficiency factors found through this analysis.

D.7 SUMMARY OF NET LONG HAUL FORECASTS

The Net Long Haul forecasts for each service for 1980, 1990, and 2000 are presented in Table D-5. These forecasts are graphed in Figure D-2.

TABLE D-4. EFFICIENCY FACTORS

	1980	1990	2000
Data Transfer	.5000	.7000	.9000
Batch Processing	.3500	.5000	.7000
Data Entry	.0031	.0124	.0484
Remote Job Entry	.0750	.1000	.1500
Inquiry/Response	.0750	.1000	.1500
Timesharing	.0750	.1000	.1500
VBPS Emss	.2000	.3000	.5000
Mailbox	.0031	.0063	.0126
Admin Traffic	.0031	.0063	.0126
Facsimile	.0750	.1000	.3000
Comm Word Processor	.1000	.2000	.4000
TWX/TELEX Mailgram/Telegram	.2000	.3000	.5000
Point of Sale	.0031	.0063	.0126
Video Text	.0750	.1000	.1500
Telemonitoring	.0031	.0063	.0063
Secure Voice	1.0000	1.0000	1.0000

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TABLE D-5. NET LONG HAUL FORECASTS

SERVICE	YEAR 1980	1990	2000
VOICE (1000's HVC's)			
MTS (Residential)	447.6	995.7	2186.3
MTS (Business)	1154.0	3217.7	7459.8
Private Line	453.1	1972.3	5472.7
Mobile	1.1	28.5	91.4
Public Radio	0.3	1.8	2.6
Commercial and Religious	0.5	2.0	3.2
Occasional	0.9	1.8	2.7
CATV Music	0.1	0.3	1.2
Recording	0.0	0.0	0.4
TOTAL	2057.5	6220.1	15220.4
DATA (Mbps)			
Data Transfer	34.2	77.0	280.7
Batch Processing	61.1	133.8	176.3
Data Entry	8616.8	12288.2	12658.1
Remote Job Entry	216.6	1392.0	1854.7
Inquiry/Response	241.6	1606.8	2813.6
Timesharing	192.7	426.2	559.3
USPS/EMSS	0.0	113.5	204.2
Mailbox	6.5	81.5	107.8
Administrative Messages	2106.4	6754.1	10953.3
Facsimile	437.3	765.2	581.7
Communicating Word Processors	13.4	51.5	102.0
TWX/TELEX	42.5	27.9	19.2
Mailgram/Telegram/Money Orders	0.2	0.3	0.4
Point of Sale	74.6	777.4	716.0
Videotext/Teletext	0.1	344.2	897.6
Telemonitoring Service	0.2	0.7	3.0
Secure Voice	1.0	32.6	188.7
TOTAL	12045.4	24873.0	32116.7
VIDEO (Transponders)			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel	0.0	0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

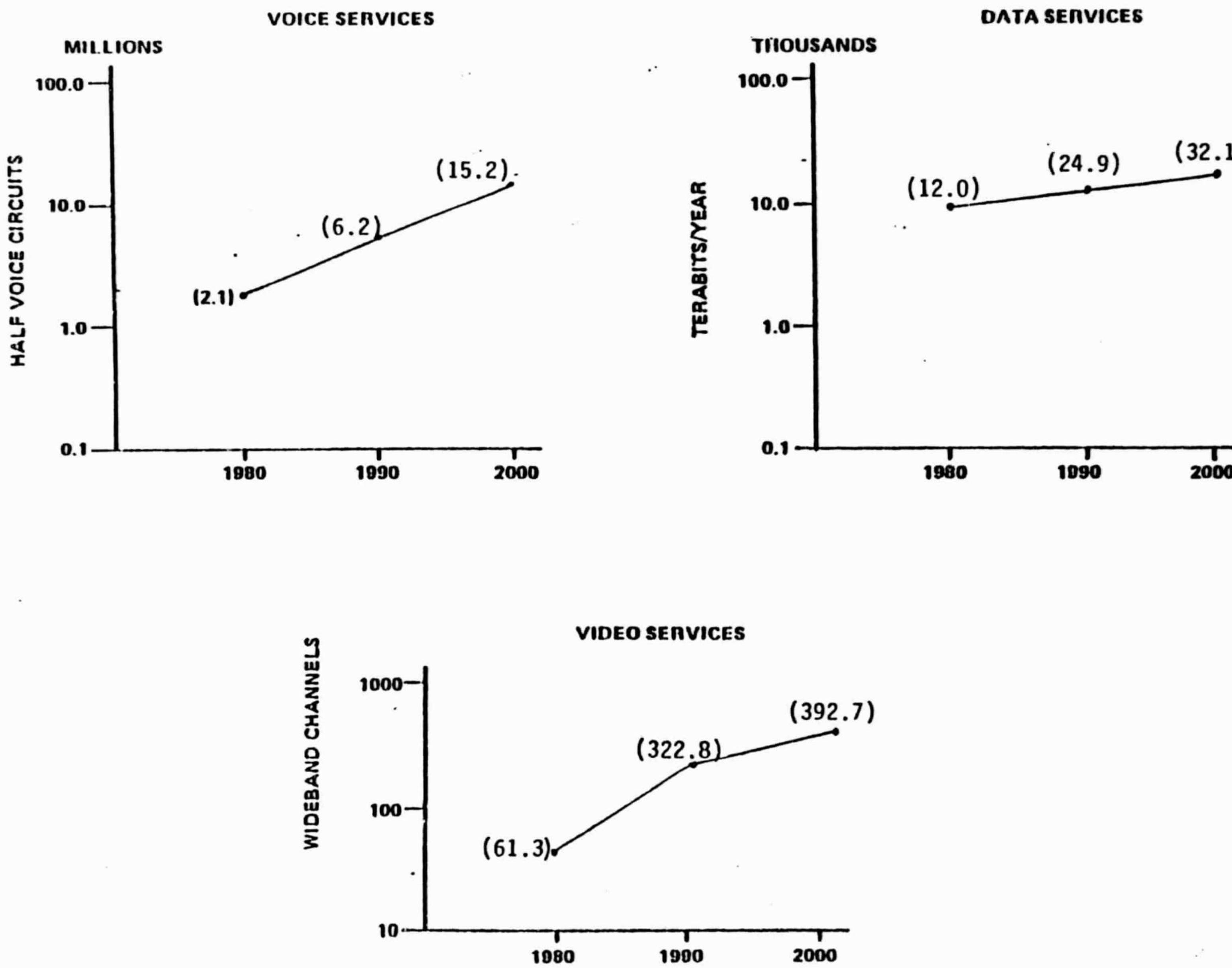

FIGURE D-2. NET LONG HAUL TRAFFIC FORECAST

APPENDIX E
TRUNKING COST ANALYSIS

E.1 TRUNKING EARTH STATION DEFINITION AND COSTS

The trunking network is designed to accomodate large amounts of traffic from a relatively small number of terminals. The traffic is concentrated to one trunking node and then transmitted. The trunking network basically consists of high density routes; as such, it needs an extensive local distribution facility at each trunking node. A trunking network can be provided by terrestrial facilities such as microwave or coaxial cable, or by interconnecting the trunking earth stations through communication satellites parked in geosynchronous orbit.

By definition, the trunking earth station is a large earth station with a high throughput capacity and is defined as that earth station which supports a capacity corresponding to a single carrier per transponder. The transmission approach used will be either TDM/TMDA, which is Time Division Multiplex (TDM) in conjunction with the Time Division Multiplex Access (TDMA), or the Frequency Division Multiplex (FDM) approach.

In the case of C-band satellites, the available transponder bandwidth is 36 MHz; the bandwidth can support 60 Mbps burst rate per single carrier for the TDM approach. For the FDM approach, depending on the signal to noise requirement, one can accomodate 1200 to 1800 VF channels per transponder.

In the Ku-band, unlike the C-band, no standard satellite seems to have emerged. There is only one existing Ku-band satellite system available and that is from Satellite Business Systems (SBS). The SBS Ku-band satellite has ten 48MHz transponders. It uses single polarization. Other Ku-band systems are being planned by GSAT, AMSAT, RCA, Southern Pacific and Rainbow Communications. These Ku-band satellite systems are in various stages of development. For purposes of computing earth station and space segment costs, a satellite similar to GSAT's is used. This type of satellite is a second generation of Ku-band satellites using dual polarization and wider bandwidth per transponder. Even though each transponder can support a maximum burst rate of 90 Mbps, the TDM single carrier trunking earth station is designed for 60 Mbps. In the FM/FDMA

mode, one transponder can support 1,500 voice channels with toll-grade voice quality.

In Ka-band (20/30 GHz) satellite systems, it is generally accepted that for trunking systems the space segment will use the Satellite Switched Time Division Multiple Access (SS-TDMA) approach. The trunking terminal, as such, is a TDMA terminal with uplink and downlink burst rates of 512 Mbps.

E.1.1 C-band Trunking Earth Station Costs

Before costing out the C-band trunking earth station, one needs to know the component costs. Several vendors of C-band satellite earth station components were contacted. The trunking earth station suppliers were also contacted. Cost estimates for various components are described in the following paragraphs.

E.1.1.1 C-band Antenna Subsystems

The typical costs of C-band antennas as a function of the diameter are presented in thousands of dollars in Table E-1 (tables follow figures at the end of this Appendix).

E.1.1.2 C-band Low Noise Amplifier (LNA) Costs

The costs of low noise amplifiers, in thousands of dollars, are presented in Table E-2 for redundant and non-redundant units. Since the availability requirement for trunking applications is quite stringent, the LNA used is in the redundant configuration.

E.1.1.3 C-band High Power Amplifier (HPA) Costs

The typical costs of C-band HPA for TWT tubes are presented in Table E-3 for redundant and non-redundant units for various sizes of TWT amplifiers. Again, for the trunking applications, the HPA is used in the redundant configuration. Table E-3 also presents the costs of klystron HPA in the redundant and non-redundant configuration. The use of klystron HPA is more economical as compared to TWT HPA at the expense of available bandwidth.

E.1.1.4 Frequency Converter Costs

The typical costs of C-band frequency converters are presented for both redundant and non-redundant configurations in Table E-4.

E.1.1.5 Costs of TDMA Terminals

The typical costs of TDMA terminals (including the burst modems) are presented in Table E-5. Costs presented are for full as well as partial transponder TDMA terminals, for both redundant and non-redundant units.

E.1.2 TDMA Earth Station Costs

The link budget for 60 Mbps burst rate TDMA terminals is presented in Table E-6 for a typical C-band satellite transponder. A typical TDMA earth station, shown in Figure E-1, consists of an 11-meter antenna, a redundant uplink (upconverter and HPA) a redundant downlink and a redundant TDMA terminal. The costs for a TDMA earth station are presented in Table E-7.

It should be noted that in Table E-7 the cost of LNA includes the transmit reject filter, waveguide/coaxial switch adapters, injection ports, etc.

Uplink subsystems include the cost of amplitude and group delay equalizers, in fact whatever hardware is needed besides the major components.

E.1.3 FDM/FDMA Earth Station Costs

Another common approach used for the trunking earth station is Frequency Division Multiplex with Frequency Division Multiple Access (FDM/FDMA). The performance and transmission parameters of the FDM/FDMA System for VF channels are determined using the following equations:

$$\frac{S}{N} = \frac{C}{N} + 20 \log \frac{Fch}{Fm} + 10 \log \frac{B}{b} + PDI + W$$

where:

$\frac{S}{N}$ = Test tone power to weighted noise power in the worst case VF channel.

B = Carson rule bandwidth or noise bandwidth.

C = 2(F + Fm)

Fch = Equivalent RMS frequency deviation due to a single channel test tone.

Fm = Highest baseband frequency 4.2 X n

n = Number of channels.

F = 3.16 g Fch

3.16 is the peak to RMS ratio of multichannel FDM signal.

g = antilog $\frac{L}{20}$

L = -15 + 10 logn for n < 240

-1 + 4 logn for 12 n ≥ 240

b = VF channel bandwidth: 3.1 kHz

PDI = Pre/DE - emphasis improvement 4 dB

W = CCIR recommended psophometric weighting factor 2.5 dB

Voice Channel Objective

The CCIR recommended noise objective is 1 X 10^4 PWPO (Picowatt Psophometrically Weighted referenced to OTLP) in the worst of FDM/FDMA System to be used for single hop satellite links. This is equivalent to 50 dB S/N. Included in this allocation are the contributions of interference, intermodulation, thermal noise and noise due to rain. The noise contributions of associated FDM multiplex are considered to be negligible.

The link budget for 1200 VF channel earth stations is presented in Table E-8 along with FM system transmission parameters. A typical earth station is fully redundant and consists of a 12-meter antenna, 40° LNA and 60° watt HPA. The costs for a FDM/FM earth station are presented in in thousands of dollars in Table E-9.

E.1.4 Ku-band Trunking Earth Station Costs

The typical component costs of the Ku-band satellite systems are obtained from various vendors and are presented in the following sections.

E.1.4.1 Ku-band Antenna Subsystem Costs

The typical costs of the Ku-band antennas as a function of the diameter are presented in in thousands of dollars in Table E-10.

E.1.4.2 Ku-band Low Noise Amplifier Costs

The typical costs of Ku-band LNA are presented in Table E-11 in thousands of dollars.

E.1.4.3 Ku-band HPA Costs

The typical costs of Ku-band HPAs are presented in Table E-12 for redundant and non-redundant units for various sizes of TWT amplifiers. For trunking applications, the HPA is used in the redundant configuration.

E.1.4.4 Frequency Converter Costs

The typical costs of Ku-band frequency converters are presented in Table E-13, both for redundant and non-redundant configurations.

E.1.5 Ku-band TDMA Earth Station Costs

The link budget for 60 Mbps burst rate TDMA terminals is presented in Table E-14 for a GSAT Ku-band transponder. A typical Ku-band 60 Mbps earth station will consist of a 7.7-meter antenna, 400 watt HPA and 125^{o} LNA. The earth station is fully redundant. The costs for this earth station are presented in Table E-15.

E.1.6 Ku-band FDM/FM Earth Station Costs

As discussed in Paragraph E.1.3, another transmission approach used for trunking earth stations is the FDM/FDMA approach. Table E-16-A presents the FM system's transmission parameters and Table E-16-B presents the Link Budget Summary for 1500 voice channel FDM/FDMA systems. A typical 1500 voice channel Ku-band earth station consists of a 7.7-meter antenna, 125° LNA, and 400-watt HPA. The earth station is fully redundant. 400-watt HPA allows 1.5 dB back-off. The costs of this earth station are presented in Table E-17. Uplink subsystems include the FM modulator downlink subsystem which includes the FM demodulator. The FM modulator/demodulator each cost about $9,000.

E.1.7 Ka-band Trunking Earth Station Cost

The baseline approach used for trunking subsystems has emerged to be time division multiplex approach with an on-board IF switch. The basic trunking service will be provided by 18 trunking terminals strategically located in high density areas. The uplink and downlink burst rate is 512 Mbps.

A typical trunking earth station consists of a 5-meter antenna, a 600-watt HPA, a 340°K LNA (system noise temperature of 600°K) and a 512-Mbps burst rate TDMA. All the components are fully redundant. Since, for Ka-band the margins required for rain attenuation are excessive, space diversity is provided for system availability levels of greater or equal to .999. The cost estimates of 512 Mbps trunking terminals are given as follows in Tables E-18A and E-18B. A typical Ka-band trunking terminal block diagram is presented in Figure E-2.

It should be noted that Ka-band costs are for the year 1990, as it is not expected to be available until 1990.

In general, manufacturing costs drop with increased production quantities and these cost reductions will be reflected in quantity orders. The cost reduction factor, commonly called a "learning curve factor" may take the following form*:

UC = Cost of a single item
F = Learning curve factor

UC_Q = Unit Cost of Quantity and

= $F^n UC$

Where,

n = Log Q/Log 2

for $2^n = Q$

A common value of F is 0.95.

For 18 earth stations, the cost will be $UC_{18} = (0.95)^n \times 4.904 = 3.96$ M

For cost of a single item of 4.905M

For cost of single item of 2.836M

UC_Q for Q = 18 is 2.3M

*Private communication with Stevenson of NASA and "Satellite Transmission Considerations in Support of 20/30 GHz Service Demand Study" prepared by FSI for WU FSI Report HO219.

E.1.8 Summary

C- and Ku-band trunking earth station costs are summarized in Table E-19.

E.2 TRUNKING SPACE SEGMENT COST

In costing end-to-end service costs, the other major component is the cost of space segment. The three types of space segments considered here are C-band space segment, Ku-band space segment, and Ka-band space segment. The approach for estimating the C-band space segment cost was to use the actual costs which were associated with one of the newer generation satellites launched by Western Union (WESTAR IV). This satellite represents the state-of-the-art C-band satellite. All C-band satellites launched recently or planned for launch are similar to WESTAR IV.

The approach used for estimating the Ku-band space segment cost was to examine the various Ku-band "FCC filings" made for various Ku-band satellites.

For Ka-band space segment cost NASA provided costs are used.

E.2.1 C-band Satellite

The typical C-band satellite technical characteristics are presented in Table E-20. Table E-21 gives the representative spacecraft weight-budget and Table E-22 gives the center frequency assignments of the 24 transponders for uplinks and downlinks.

A typical C-band satellite comprises of 24, 36 MHz wide transponders. It uses horizontal and vertical polarization. Figure 1, presented earlier, illustrates the typical C-band communication systems. Space segment costs consist of the following cost elements:

a. Satellite development cost
b. Recurring satellite cost
c. Launch costs
d. TT&C and satellite control center costs
e. Operation and maintenance costs.

For C-band satellite it is assumed there is no development cost associated since they are becoming standardized.

By examining the costs associated with WESTAR IV and looking at various FCC filings the cost estimates are as follows for C-band satellite:

Cost of a C-band satellite including launch and insurance and other overhead	= \$ 78 million
Telemetry tracking and command (TT&C) and satellite control center costs	= \$ 15 million
Operation and maintenance cost per year	= \$ 1 million
Cost of C-band satellite	= \$ 30 million

- o Launch cost approximately 30 million dollars.
  Insurance cost is 9 million dollars.

For a typical satellite system it is assumed that to begin two satellites will be launched and one will be a ground spare. The initial investment (I) is then:

$$I = N(R+L+IN)+R+NR+TT\&C$$

where N = Number of satellites launched

R = Satellite cost

L = Launch costs

IN = Insurance cost

NR = Development cost or non-recurring cost

TT&C = Cost associated with TT&C and satellite control centre

For a C-band system

I = 201 million

This does not include the operation and maintenance cost.

E.2.2 Ku-band Satellite Costs

In C-band satellite systems, more or less a typical satellite has emerged, but in Ku-band satellite systems, various types of satellites are being planned. The SBS Ku-band satellite uses single polarization and comprises of 10, 48-Mhz wide transponders, whereas "GTE" uses dual polarization and "GSTAR" comprises of 16, 54-Mhz wide transponders. The Southern Pacific's satellite is hybrid, using both C-band and Ku-band transponders. Ku-band transponder is 72-Mhz wide. For the purpose of this study Ku-band satellite similar to GTE will be assumed. Table E-23 summarizes the primary operational characteristics of the satellite; while Table E-24 gives the representative spacecraft weight budget.

Functional block diagram of Ku-band dual polarized, satellite repeater is shown in Figure E-3 with eight vertical and eight horizontal polarized transponders. The cost elements of space segment are the same as outlined in Paragraph 2.1. The costs for these elements are given below:

Development	$34	million
Cost of satellite including launch	$70	million
Telementry tracking and command (TT&C) and satellite control center	$15	million
Cost of Ku-band satellite	$35.7	million

Operation and maintenance	\$1 million
Insurance cost	\$11.9 million

For a typical satellite system, two satellites will be launched and one will be a ground spare. Insurance cost is about 17 percent of the total satellite and launch cost. The initial investment is 248.5 million dollars. The operation and maintenance cost per year is one million dollars.

E.2.3 Ka-band Space Segment for Trunking

The approach used for trunking subsystem in Ka-band has emerged to be TDMA approach, with an on-board SS-TDMA Switch. The basic trunking service will be provided by 18 0.3° fixed beams each connected to a 500 Mhz dual output power (75w/10w) transponder. Three separate carrier frequencies (each with a 500 MHz Bandwidth) each reused on 6 of the fixed beams will be used. Complete trunking interconnectivity is provided using 512 Mbps, satellite switched TDMA channels which requires a 20 x 20 IF Switch matrix in the satellite, programmable from a master control station to satisfy changing traffic patterns.

Although the maximum throughput is 9 GBPS, this will only be achievable for a completely balanced traffic pattern. A more realistic achievable throughput, should be about 4 GBPS.

A functional block diagram for Ka-band trunking subsystem was presented earlier in Figure E-2. This also presented the CPS function of the spacecraft. For the trunking case, an 18 beam spacecraft is estimated to weigh approximately 3000 pounds, and require approximately 1600 watts of beginning of life (BOL) power.

The costs are estimated to be as follows

Non-recurring (spacecraft, propulsion, integration)	=	\$160 million
Recurring (spacecraft, propulsion, integration) x 2	=	\$90 million
Launch x 1	=	\$24 million

Master control facility	=	\$40 million
Insurance Cost	=	\$11.73 million
O & M cost/year	=	\$2 million

For a typical satellite system, one satellite will be launched and one will be a ground spare. Insurance cost is about 17 percent of the total satellite and launch cost. The initial investment is 326 million dollars. The operation and maintenance cost per year is 2 million dollars.

E.2.4 C-, Ku-band Transponder Price

The total investment for C-band satellite systems as estimated in Paragraph 2.1 is 201 million dollars with yearly operational and maintenance expenditures of 1 million dollars. The price per transponder is estimated using the model shown in Figure E-4. The "WU" proprietary financial package was used to determine the estimate of all loadings and profits for the life of the system. The package considers such factors as cost of money, depreciation, return on investment, project management and administration costs, etc. Figure E-4 also shows the price per C-band transponder for eight and ten year system life. It is seen that the transponder price per year is 1.81 M for eight year life cycle, whereas for ten year life cycle the price is 1.70 million/year. Western Union presently leases the C-band transponder for 2 million dollars/year.

Figure E-5 shows that Ku-band transponder price is 3.43 M/year for eight year life cycle, whereas for ten year system life the price is 3.21 M dollars/year.

It should be noted that in both C- and Ku-band it has been assumed that as soon as the satellites are launched, half of the transponders will be used. The demand for remaining transponders will grow linearly through the life of the satellite, i.e., on the average three-fourths of the number of transponders will be used.

E.2.5 Ka-band Equivalent Transponder Cost

In Paragraph E.2.3, it was seen that for space segment, the total capacity available is 9 GBPS for the trunking configuration under consideration. The equivalent number of transponders available is then 150. Due to unbalance of

traffic a more realistic achievable throughput is about 67 transponders. It is assumed that average number of equivalent transponders used through the life of trunking satellite is 40, which corresponds to an average usage of 60 percent. The annual recurring cost of an equivalent transponder as modelled in Figure E-6 is 2.54 M $/Year based on 10 year life of the Ka-band satellite.

E.2.6 Bibliography

a. Memo from C. Bhushan to J. Lekan dated May 5, 1982.

b. Memo from J. Lekan to C. Bhushan received May 18, 1982.

c. Private communication with Mr. Grady Stevens of NASA.

d. "Customer premise service study for 30/20 Ghz satellite systems," Third Interim report by TRW dated February 4, 1982.

e. Presentation by Grady Stevens at NASA industrial facility.

f. "CPS Study for 30/20 Ghz satellite systems space segment concepts," presented by TRW at NASA industrial facility April, 1982.

g. B. I. Edelson et al, "Greater message capacity for satellites," IEEE Spectrum March, 1982.

h. "30/20 Ghz mixed user architecture Development Study."

i. Memo from S. M. Stevenson to C. Bhushan dated August 19, 1982.

E.3 TRUNKING ENTRANCE/EXIT LINKS

E.3.1 Terrestrial Microwave Systems

Terrestrial microwave systems have been widely used for entrance/exit links. Numerous installations already made have demonstrated that microwave systems can be engineered to be equally reliable as the conventional cable systems.

E.3.1.1 System Design Configuration

E.3.1.1.1 Microwave Analog Radio

Microwave analog radios have traditionally used frequency modulation (FM) to impart the information in a frequency division multiplex (FDM) baseband on a radio carrier. The main advantage of FM is the improved signal to noise ratio above the FM threshold (FM improvement threshold). Design factors for a radio-link hop include the determination of tower heights by path profiling and path calculations. From the latter, the system designer derives the necessary equipment parameters. Figure E-7a and E-7b is a block diagram showing the entrance/exit link using analog radio.

E.3.1.1.2 Digital Microwave Radio

Digital microwave radio systems have become an important part of the total voice and data transmission field in a very short period of time. Early systems used QPSK to achieve efficiencies of approximately 1 bps per Hz. Today, 8 PSK and 16 QAM are being used to achieve transmission efficiencies of 3 bps per Hz.

When designing high capacity systems, several factors must be considered. First, there are often regulatory constraints on occupied RF bandwidth, spectrum shape and bandwidth utilization. Second, generally there are some constraints on channel capacity that arises from the need for standard digital interfaces. Third, the complexity of the modulation technique must not become so high that it is impossible to obtain acceptable performance during multipath propagation conditions. Finally, the inherent signal to noise ratio (S/N) along with the transmit power level and receive noise figure will establish the system gain of the equipment. Figure E-8 shows an entrance/exit link using a 90 Mbps digital radio.

E.3.1.2 System Costs

E.3.1.2.1 Assumptions

The costs are based on the assumptions outlined below:

a. Analog systems will be designed using heterodyne hot standby radios with a capacity of 1200 VF channels. Digital systems will be designed using solid-state duplex protected microwave radio with a capacity of 1344 digitized voice channels.

b. Single antenna system using ellipitical wavguide will be used throughout.

c. Fault and alarm system will be tied to an existing master station. Costs for remote control operation is included at terminals.

d. A typical 5 KVA diesel engine generator with automatic switching is included at city terminals and 10 KVA at repeaters.

e. City sites will be leased and no land costs are included.

f. Prefabricated building will be used at all repeater locations.

g. Civil work and land estimates are based on average costs. Actual costs will vary considerably from site to site.

h. Single polarization scheme with standard RF branching configuration is priced in.

i. Average test equipment costs are included for city terminals and repeaters.

j. The interface at the earth station is at supergroup level for analog radio and DS1 level for digital radio and fiber optic systems.

Tables E-25, E-26 and E-27 show analog and digital radio terminal, repeater and multiplex equipment. From these tables, the cost of a radio system, fully equipped down to the channel level was worked out (see Table E-28), was fed to the computer and annualized costs per channel are shown in Table E-29.

E.3.2 Optical Fiber Cable Systems

E.3.2.1 Introduction

There is no doubt that optical transmission and glass fibers will become a dominant transmission technology in the future. The use of fiber optics provides an unlimited number of channels by virtue of being a cable medium, and provides superior economics by virtue of low loss and wide bandwidth.

Today, fiber-optics technology has already reached the state of full-scale production and wide applications for short and long haul trunking.

E.3.2.2 System Design Configuration

The first step to be taken in designing a lightwave system is the selection of an operating wavelength. The factors affecting the wavelength include optical fiber loss versus wavelength, equipment gain versus operating wavelength, optical fiber bandwidth versus wavelength, optical fiber bandwidth versus distance and the economics of operating wavelength.

The second step is the calculation of link loss budget. The factors affecting the link loss budget include: intrinsic loss of the optical fiber, splice losses, connector losses, allowance for system degradation due to noise and finally operating margin.

Figure E-9 shows an entrance/exit link using a 90 Mbps optical fiber system.

E.3.2.3 System Costs

The cost of fiber optic transmission system at each terminal is based on two M13 multiplexers including redundant common equipment, two 90 Mbps optical terminals (1 main and 1 spare) with 1 x 1 protection switching and all the required alarms and power distribution panels. The repeater is placed at a distance of 25 Km from each terminal and housed in a weather-proof enclosure which includes charges and standby batteries sufficient for eight hours of standby power. A typical 5 KVA diesel engine generator with automatic switching is included at city terminal.

The cable to be used is of premium quality, with attenuation less than 1 dB/Km at 1300 nm and has an end-to-end dispersion of less than 6 ns. The cable consists of four fibers, one fiber working and one spare for each direction of transmission.

Table E-28, noted earlier, shows the costs for hardware and cable including installation. Installation of entrance/exit cable is assumed to be as follows:

15 KM through rural area (trenching)
20 KM through suburb area
15 KM through a large city

The costs of multiplex equipment was shown in Table E-27. The total cost for a fiber optic system equipped for 38 T1 circuits is $890,000. In addition, duct lease and right of way are estimated to be $167,000 per year.

Table E-29, noted earlier, shows the annualized cost per channel using analog radio, digital radio and fiber optic systems. It can be seen that analog radio is more economical when used for voice frequency transmission.

E.3.3 Technology for Future Systems

E.3.3.1 Introduction

Some of the important advances in digital transmission in the years ahead will include increased capacity through the use of new modulation systems and data compression schemes; increased span length in fiber optic systems; new service including digital video; and significant equipment improvements made possible by the use of new devices.

The major system technologies to be discussed are: high capacity digital radio and time assigned speech interpretation.

E.3.3.2 High Capacity Digital Radio

Present capacity of digital radio is two DS3 (44.786 Mbps) rate in the standard North American traffic interface. The logical next step is to increase the capacity of the future digital radio in DS3 increments i.e., future radio will have a capacity of three DS3 by 1990 and four DS3 by the year 2000. Other factors which must be considered for higher capacity digital radio are the regulatory constraints on occupied RF bandwidth, spectrum shape and bandwidth utilization, the complexity of the modulation technique and its effect on obtaining acceptable performance system parameters.

It is apparent that future higher capacity digital radio systems will utilize combinational modulation techniques with efficiencies of 4.5 to 6 bits per second per Hz. This implies that the systems will use linear transmitter structures. To achieve these efficiencies, high level QAM techniques will be required. Figure E-10 shows the channel capacity for various modulation schemes.

E.3.3.3 Time-Assigned Speech Interpolation (TASI)

The use of TASI permits an increase in the voice channel capacity of a digital transmission system. TASI, originally designed for analog submarine cable operation, is well suited to digital voice circuits. It makes use of the fact that a typical voice circuit is active about 40 percent of the time during a conversation. The basic principle is to monitor activity and assign only the active channels for transmission. Competition for available channels may lead to clipping. The effective gain in capacity is presently about two. By utilizing predictive algorithms, system gain will increase to three or four. It is anticipated that TASI will impact the cost of switched voice circuits rather than dedicated circuits.

E.3.3.4 Fiber Optic Devices

The predominant form of fibers utilized today for fiber optic cables is the multimode, graded index fibers. The loss of characteristics of this fiber is shown in Figure E-11. The theoretical limit in bandwidth of this type of fiber is about 10 GHz per Km, although the practical limit is in the range of 1 to 2 GHz.

The predominant wavelength of today's installed fiber optic systems is 850 nm. The loss at this wavelength is in 2.5 to 3 dB/Km range. To achieve the system gain necessary for a system with reasonable margin, it is necessary to use laser transmitters and avalanche photo detector receivers.

The window of 1300 nm loss approaching 0.6 dB/Km is very attractive and will have considerable application. Increases span length can be obtained at the 1300 nm wavelength. It is possible to increase the capacity of a fiber by the use of wavelength multiplexing.

E.3.4 Future Costs

E.3.4.1 Digital Radio Systems

The future technology trend is to expand the channel capacity of digital. However, this trend will not have an impact on the cost of the entrance/exit links due to the capacity of the link being maintained at 90 Mbps. There will be an anticipated slight reduction due to LSI and miniaturization of equipment, namely 5 percent and 15 percent in 1990 and 2000, respectively.

Table E-30 shows the annualized cost per channel using the above factors.

E.3.4.2 Optical Fiber System

The cost of fibers and optical equipment have been dropping substantially for the last few years. It is predicted that the costs of fibers and equipment will be dropping at a rate of 15 percent per year until 2000. Since the bulk of the cost of the system is derived from laying the cable, duct lease and right of way, the annual cost will be reduced by 30 percent and 40 percent in 1990 and 2000, respectively. Table E-31 shows the annualized cost per channel.

E.4 TRUNKING NETWORK COSTS AND CROSSOVER DISTANCES WITH TERRESTRIAL TARIFFS (1982)

The cost components of a trunking network are:

a. Space segment cost
b. Earth segment cost
c. Terrestrial segment cost
d. Central network control facility.

In the following sections, the costs are derived for the trunking network.

E.4.1 Trunking Network Costs for TDMA Networks (C- Ku- and Ka-band)

For the purpose of the TDMA trunking network, the following assumptions are made.

a. The network consists of 10 nodes.
b. The transmit and receive capacity at each node is 60 Mbps.
c. At frame efficiency of .95, the TX capacity between any two nodes is 6.3 Mbps.
d. The interface to terrestrial segment is at the T1 level.
e. The terrestrial segment is assumed to be digital to retain the full flexibility of the TDMA approach.

In this configuration, every earth station has the receive capability from the other nine earth stations, which are transmitting with different transponders. Thus, each earth station consists of one uplink chain and nine downlink chains. thus, the cost of trunking earth stations are as calculated in Paragraph E.1-E.1.8, Table E-7 and Table E-15 for C and Ku-band respectively, in addition to eight down-link chains. For C-band, it is assumed that the earth station is located on the average of two microwave hops away from the central office and digital microwave interfaces to the TDMA at the T1 rate. For Ku-band, the earth station is assumed to be colocated with the central office.

C-band

Earth station cost = 709 + 8 X 38.8 + 38 X 6 = 1247.4K
Installation and integration cost = 499K
Total earth station cost = 1746.0

Ku-band

Earth station cost = 642.8 + 8 X 38.8 = 953.2

Installation and integration cost = 381.3

Total earth station cost = 1334.5

E.4.1.1 C-band Trunking Network TDMA Approach

The various cost components are as follows:

Earth station = 17 million dollars

Annual earth segment cost = 6.97 x 10^6 million dollars

Based on 10 year depreciation

Annual space segment cost = 17 million dollars

Central network control facility = 500K dollars

Annual central network control facility = 205K dollars

This annual payoff for different services is given in Table E-32.

E.4.1.2 Ku-band Trunking Network

The various cost components are as follows:

Earth segment cost = 13.35 million dollars

Annual payoff = 5.5 million dollars

Annual space segment cost = 32.1 million dollars

Annual central network control facility = 205K dollars

Annual revenue requirements = 37.8 million dollars

The annual payoff requirement for different services is given in Table E-32.

E.4.1.3 Ka-band Trunking Network

For Ka-band trunking networks, it is assumed that:

a. The trunking network consists of 18 nodes.

b. Each node is connected to a 500 MHz beam. Trunking services are provided by 18, 0 to .3° fixed beam.

c. Three separate carrier frequencies, each reused on 6 of the fixed beams.

d. Complete trunking interconnectivity is provided by using satellite switched TDMA approach.

e. A 20 by 20 IF switch matrix is used on board the satellite, programmable from a master control station to satisfy changing traffic patterns.

f. Maximum throughput is 9 GBPS. Due to traffic imbalance, realistic achievable throughput is assumed to be 4 GBPS.

g. For Ka-band, it is assumed that the satellite earth station is colocated with the central office.

E.4.1.3.1 Ka-band Trunking Network Costs

Various cost components as provided by NASA are as follows:

Development cost for trunking terminal = 3.3M
Earth segment costs = 18 X 3.96 = 71.3M
Central network control facility = 1.5M
Total ground segment investment = 76.1M
Annual recurring cost for ground segment = 31.2M
Annualization factor of 41% is used.
Annual revenue requirement for space segment = 101.76M
Total annual revenue requirement = 132.96M

Various cost components, developed through internal Western Union analysis, are as follows:

Development cost for trunking terminal = $3.3M
Earth segment cost = 18 X 2.3 = 41.4M
Central network control facility = 1.5M
Total ground segment investment = 46.2M
Annual recurring cost for ground segment = 18.94M

Annual revenue requirement for space segment = 101.76M

Total annual revenue requirement = 120.7M

E.4.2 C and Ku-band FDM Trunking Costs

E.4.2.1 C-band

For the purpose of FDM/FDMA trunking networks, the following assumptions are made:

a. The network consists of 10 nodes.

b. The transmit and receive capacity at each node is 1200 VF.

c. At the fill factor of 0.9, the transmit capacity between any two nodes is 120 VFs.

In this configuration also, every earth station has the receive capability from the nine earth stations which are transmitting at different transponder frequencies. Thus, each earth station consists of one uplink chain and nine downlink chains. Thus the cost of trunking earth stations are as calculated in Paragraph E.1, Table E-9, in addition to eight downlink chains. The cost of trunking earth stations in this configuration is then:

Earth station cost = 506.5 + 8 X 45.4 = 870.5K dollars

Installation and integration cost = 348.2K dollars

Total earth station cost = 1219K dollars

Annual earth station price based on the 10 year depreciation = 499.8K dollars

Annual earth segment price (10 earth stations) = 5.0M dollars

Annual space segment price (10 transponders) = 17M dollars

Annual network control facility = 205K dollars

Total annual payoff requirement = 22.2M dollars

The annual payoff for different services is given in Table E-32.

Note that analog systems are not very cost economic for digital services.

E.4.2.2 Ku-band

For the purpose of Ku-band FDM/FDMA trunking network, the following assumptions are made:

a. The network consists of 10 nodes.

b. The transmit and receive capacity at each node is 1500 VF.

c. At the fill factor of .9, the transmit capacity between any two nodes is 135 VFs.

The cost of trunking earth stations in this configuration is the cost of earth stations as calculated in Section 1, Table E-17, in addition to eight downlink chains.

Earth station cost = 429.5 + 8 X 45.5 = 793.5K dollars
Installation and integration cost = 317.4K dollars
Total earth station cost = 1110.9K dollars
Annual earth station revenue requirement based on 10 year depreciation = 456K dollars
Annual earth segment price (10 earth stations) = 4.56M dollars
Annual space segment price (10 transponders) 32.1M dollars
Annual network control facility = .2
Total annual payoff requirement = 36.9

The annual payoff for different services is given in Table E-32. It is seen that analog systems are not very cost effective for digital services.

E.4.3 Terrestrial Segment Cost

In Section 3, different technologies were examined for provision of terrestrial tail segments. Presently, it seems the most cost effective way of providing terrestrial segments is digital radio. For voice service, also, the cost of tail circuit, using digital radio as compared to analog radio is not very different. Table E-33 presents the annual revenue requirement, for both ends of terrestrial tail, for digital and analog radio and fibre optics for various types of services. It should be noted that for C-band it is assumed that the central office is 50

kilometers away from trunking earth stations, while for Ku- and Ka-band, it seems reasonable to assume that trunking earth stations are colocated with the central office. For local subscriber loops, telco tariffs are used, it is assumed that the subscriber is within 5 kilometers of the central office. the terrestrial tail annual costs include the channel unit costs, also. For the TDMA approach, it is assumed that tail segments use digital radio, whereas for the FDM/FDMA approach, it is assumed that analog radio is used.

E.4.4 Terrestrial Tariffs

For comparison of satellite end-to-end user costs with terrestrial systems, AT&T terrestrial tariffs are used. Comparative service tariffs used are as follows:

SERVICE	FACILITY	TARIFF TYPE
Voice	300 to 3000 Hz	FCC No. 260
	Private Line	Type 2001
Data	2.4, 4.8, 9.6, and	FCC No. 267
	56 KBPS	FCC No. 271
	1.544 MBPS	for Termination

E.4.5 Break Even Distances

A review of terrestrial tariffs indicates that the filed tariffs are distance sensitive, whereas, the satellite end-to-end user costs are distance independent. The break even distance is defined to be that distance where the end-to-end costs by satellite is equal to that of the terrestrial cost as compared by using terrestrial tariffs for an equivalent service. At a distance lower than break even, the terrestrial service is more cost effective, whereas, at a distance greater than break even, the satellite service is cheaper. Appendix 1 outlines the tariffs. The break even distances are summarized in Table E-34.

E.5 FUTURE TRENDS

E.5.1 Digital Trends

Because of the communication trend towards total digital systems, as opposed to analog sytems, it was assumed that in 1990 and 2000, the communication will be entirely digital. The reason behind this trend is twofold:

a. Availability of digital microcircuitry at reasonable prices, which makes digital processing cost effective (see references).
b. The requirements for integrated services.

E.5.2 Capacity Improvement Techniques

Presently in digital transmission schemes, the TDM/TDMA approach with quadrature phase shift keying (QPKS) is being used. With this approach a typical C-band 36 MHz wide transponder could transmit 60 Mbps of information. It is anticipated that by the year 1990 more spectrally efficient modulation schemes will be used. It is assumed that in 1990 the transmit capacity of a typical C-band transponder will increase by 50% to 90 Mbps.

Presently for digital transmissions of voice, 64 Kbps pulse code modulation (PCM) is used. In year 1990 it is assumed that voice will be transmitted at 32 Kbps, thus the number of voice channels per transponder could increase by 2. Voice activity compression could also be used for voice circuits which would further increase the voice handling capacity by 2. Thus the voice channel capacity per transponder could quadruple with 32 kbps coding and implementation of voice activity compression.

It is anticipated that the preferred approach in the future will be the TDM/TDMA, be it in earth station or space segment. For microprocessor-based hardware, the price has been falling at an average rate of 7% a year for nearly 20 years, in spite of inflation. That trend shows no sign of bottoming out, as more uses are found for the very large scale integrated circuits (VLSI). Since TDM/TDMA design can be based on microprocessors (some manufacturers have already designed TDM/TDMA equipment based on microprocessors) in conjunction with software (for routing, formatting, framing, synchronization, encoding,

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forward error connection), it is anticipated that cost of the TDM/TDMA terminals will also reduce at a rate of 15% (in 82 dollars) until 1990 and 10% until the year 2000. Cost projections of TDMA terminals are given below:

COST OF TDMA TERMINALS IN THOUSANDS OF DOLLARS IN 1982

Year	Burst Rate	60 MBPS	15 MBPS	8 MBPS
1982	Non-redundant	140	50	40
	Redundant	240	80	58
1990	Non-redundant	34.1	13.82	11.00
	Redundant	55	21.8	16.00
2000	Non-redundant	12	5.00	3.8
	Redundant	19.2	7.60	5.6

Presently it is seen that the price of common equipment allocated to a particular service is quite negligible as compared to channel derivation cost. For example, for a large CPS earth station, the common equipment price for 2.4 Kbps end-to-end channel with C-band transponder is only $179/year whereas the annual recurring price for 2.4 KBPS channel units at both ends is $4,000/year. For rates up to 56 KBPS the channel unit price contributes heavily to end-to-end service costs. It is anticipated that plug-in channel units will also be microprocessor based and costs will come down at the same rate as TDMA equipment. Cost projections of various channel units are given below:

COST OF CHANNEL UNITS IN THOUSANDS OF DOLLARS

Year	Voice	2.4 KBPS	4.8 KBPS	9.6 KBPS	56 KBPS	1.5 MBPS	6.3 MBPS
1982	0.7	3.5	3.5	3.5	3.5	6	9
1990	0.2	1.0	1.0	1.0	1.0	1.6	2.5
2000	0.07	0.3	0.3	0.3	0.3	0.56	0.84

E.5.3 Radio Frequency (R F) Components

Major earth station R F components included are low noise amplifiers (LNAs), high power amplifiers (HPAs), and antennas. The following sections will discuss technology advancements in these areas.

E.5.3.1 Low Noise Amplifiers (LNA)

The LNA for satellite communications are of two types: the paraamp LNA and FET LNA. The cryogenically-cooled paraamp LNA was extensively used in the infancy of satellite communications but due to maintenance difficulties and high cost it is hardly used today. The thermoelectrically-cooled and uncooled parametric LNAs are used in large earth stations. Those LNAs feature almost as low noise temperature as do the cryogenically-cooled parametric LNAs, due to improvements in the Varactor and increased pump efficiencies.

The FET LNA is employed mainly for DOMSAT and especially for TVRO systems. Thermoelectrically-cooled and uncooled versions are used almost universally for those applications. For C-band typical noise temperature curves of 35° K T E cooled 45° K T E cooled, 55° K uncooled paraamp LNAs , T E cooled 80° K FET LNA and uncooled 100° K FET LNA are shown in Figure-12. FET LNA is maintenance free and is more reliable than the parametric LNA.

The C-band LNA has made excellent technological progress in the past, and it is expected that by year 1990 it will be possible to realize noise temperature below 30°K for parametric LNA and 70°K for the FET LNA. The LNAs will get smaller and smaller and eventually LNA will take up only a small part of antenna installation. It is expected that LNA will eventually be reduced to about half its present size.

Ku-band (14/12 GHz) has come to be utilized as a second generation satellite communications band. In fact, Satellite Business Systems (SBS) has already launched two Ku-band satellites and will be launching a third satellite later this year. The two types of LNAs discussed above are used in Ku-band also. The major problem with 12 GHz LNAs is the increase in noise temperature contributions by connecting components such as wave guide switches and lines. At this frequency the overall design configurations become extremely important.

Typical noise temperatures for TE-cooled paraamp, LNA, uncooled parametric LNA, TE-cooled FET and uncooled FET are shown in Figure-13.

It is expected that the noise temperature performance of TE-cooled FET LNA will approach that of the uncooled parametric LNA in the future. Due to this only TE-cooled parametric LNA is expected to find application. A minimum noise temperature of 80° is expected for TE-cooled parametric LNA, while TE-cooled FET LNA will attain noise temperatures of less than 130°K as opposed to its present 150°K.

E.5.3.2 Power Amplifiers

The technological evolution in the area of power amplifiers has not kept pace with the rapid technological advances of LNA, but the advent of power FET has provided another alternative to traveling wave tubes (TWT) and IMPATT amplifiers for earth stations and satellite transponder application for power levels up to 10 watts at C-band. In space application (for communication payloads) the trend is towards higher powered transponders, which make earth stations smaller.

For earth terminals, both klystrons and TWT's serve the uplink with power levels of up to 10 K watts at 8.2 Ghz, 2 K watts at 14.5 Ghz and 800 watts at 30 GHz available from manufacturers in Japan and Europe. The TWT and klystron HPAs are nonlinear devices. The effect of nonlinearity is that the output signal not only contains the fundamental frequency but also harmonics which introduce distortion in the signal. Another effect is the intermodulation products for multi-carrier operation of the transponder. Because of these effects, the HPA is normally operated in backed off mode in the linear region, which reduces the available power and hence the capacity. A lot of research is going on in the area of linearizing HPAs. It is anticipated that in the future substantial linearization will be achieved. With linearization of HPA one can either increase the transponder capacity or reduce the size of the tube.

For space applications, TWTs have been the mainstay of communication transponders from the beginning of satellite communications. Current TWTs provide efficiencies up to 40% and have an operational life of 7 years or more. There has been considerable effort to develop solid state counterparts for TWT power amplifiers. Impact diodes have an edge at frequencies above 20 GHz; the real impact at bands of intermediate frequencies is being made by GAS FET amplifiers.

GAS FET amplifiers are expected to provide comparable efficiencies, better IM products, smaller volume and of course, simpler power supplies. It is expected that at C- and Ku-bands GAS FET amplifiers will be used, reducing satellite size and weight requirements and increasing operational life. For frequencies over 20 GHz Impatt amplifiers are expected to be used. As yet there are no plans beyond utilization of Ka-band (20/30 GHz) communications satellites. Gyrotron amplifiers may eventually make it possible to handle telecommunication requirements at 35 GHz and beyond. It is reported in the literature that development of such tubes is proceeding with encouraging results.

E.5.3.3 Antennas

The antennas for initial communications satellites were area coverage type i.e., a single beam covering the whole or a major part of the visible portion of the earth and radiating all the available frequencies only once. They were a very small fraction (1%) of total end of life (EOL) mass of the satellite. Antennas have become more complicated through the years and weigh about 9% of the spacecraft mass and 30% of the total communication subsystem mass. Technological trends in the design of COMSAT antennas are:

a. Multiple frequency bands
b. Greater bandwidths
c. Multiple beam antennas
d. Higher EIRPS (i.e., higher efficiencies and larger apertures)
e. More feed elements
f. Improved spacecraft pointing accuracies
g. Greater antenna subsystem mass
h. Deployable antennas
i. Reconfigurable and steerable antennas
j. Improved sidelobe performance
k Improved polarization performance
l Extreme thermal environment.

As the trend towards complicated antennas grows, the material technology is becoming an increasingly important aspect of antenna design. Demand for lightweight thermally stable materials such as graphite film reinforced plastic

GFRP (RF reflective) and Kevlar epoxy (RF transparent) will grow as surface accuracy and temperature environments become more stringent. This will reduce the weight of antenna subsystems. It should be noted that spacecraft antenna performance will play an important role in realizing higher communications capabilities in satellites. Research and development efforts are continuing in the area of innovative feed systems, beam forming networks and reflector, lens, or array aperture configurations.

E.5.4 Transponder Trends

When the initial communications satellite was launched, its basic function was frequency conversion and signal amplification. There was one beam per transponder. A frequency band was used only once. This transponder configuration is shown in Figure E-14.

The next step was to use dual polarization schemes and frequency reuse factor was increased by 2. The DOMSATS had 24 transponders, the two transponders using the same frequency with dual polarization. The configuration of this transponder is shown in Table E-35.

The connection between transponders is achieved through the earth stations primarily by frequency hopping techniques. All the domestic communication satellites in C-band are of this type. Case II shows a multibeam transponder. The transponders are connected by a radio frequency (RF) switch matrix or IF switch matrix (GE and Ford Aerospace are developing these IF switch matrices for Ka-band satellites under contract for NASA. Advanced WESTAR, to be launched in the near future, will use 4 x 4 switch matrix for Ku-band transponder. The EIRP and G/T are improved by the increased gain of multibeam antenna. The increased capacity is then transmitted via satellite transponders. The interconnection between various beams may be obtained by means of a FDM-FDMA approach or SS-TDMA approach. Due to advances in digital technology, SS-TDMA seems to be a more viable technology.

Case III shows a transponder using on-board regeneration technology. Signal processing is performed digitally on-board the satellite. The effects of regeneration are:

a. Decoupling of uplinks and downlinks

b. Improvement of signal quality due to signal processing, such as error correction decoding and encoding

c. Use of TDM signal for the downlink simplifies the earth station configuration.

Case IV is a combination of Case II and Case III. It uses multibeam transponders with on-board regenerative technology. Beam switching is performed in time division baseband processor.

Case V shows the transponder configuration performing signal speed conversions along with regeneration. The advantage of this approach is flexibility in earth station design. In addition, earth station design can be customized to a subscriber's need.

Case VI shows the ultimate satellite design which employs an IF s[illegible] for multibeam connectivity for high speed (bit rate) beams. This will be [illegible]ed for high speed trunking applications. It also employs a regenerative techn[illegible]ogy for low speed customer premises services. This is the type of transponder approach being proposed for Ka-band satellites. It also provides connectivity between trunking and CPS users. It is expected that by 1990 the technology will support the launch of such a communications payload. In addition to the evolution in transponder technology there is a trend towards ever larger satellites with multiple mission capabilities and multiple users and ownership. This concept is that of space platforms. These structures are expected to have a capability of progressive addition and/or replacement of parts of the payloads. The size and weight of a space platform will be a function of the capabilities of available launch vehicles. Figure E-15 summarizes the increase in launch vehicle capability.

E.5.5 Technology Impacts on Cost

It is expected that costs of RF portion of the earth stations will come down by 3% a year because of the expected technological advances forecasted for the future. M&C subsystem being based on microprocessors in conjunction with software will also reduce by the same factors as TDMA.

E.5.6 Impact of Technology on Transponder Prices

In the previous section technology trends and advances were discussed in the areas which could impact the satellite costs.

E.5.6.1 C-band

C-band satellites have been used for about a decade for domestic communications in US and Canada, and it is felt that costs of C-band sateliltes will stay at the same level as they are today. The reasons are:

a. C-band satellite spacing will always be higher as compared to Ku- and Ka-band
b. C-band is most suitable frequency spectrum for communications from the propagation characteristics and availability point of view.

Even though the transponder price will stay constant, the amount of information which could be hauled through a standard 36 MHz C-band transponder will increase to 90 MBPS by 1990.

a. Most suitable for broadcast applications
b. Technology is quite mature at C-band.

E.5.6.2 Ku-band

Presently Ku-band transponder annual payoff requirement is almost twice that of a C-band transponder. As Ku-band technology matures and more and more Ku-band satellites are launched, it is felt that the Ku-band transponder prices will reduce and finally level off at the same value as C-band. With this assumption the price will reduce at 3.5% per year. The factors by which prices will be reduced by 1990 and 2000 are given below.

	1982	1990	2000
Transponder lease price	1	0.75	0.53

In addition to the price reduction, the transponder will transmit 90 Mbps instead of 60 Mbps by year 1990, as the bandwidth per Ku-band transponder is increased. By 2000 it is felt that due to more efficient modulation techniques a Ku-band transponder will transmit 135 Mbps.

E.5.6.3 Ka-band Satellite

Ka-band systems are still in the planning and development stages and it is not known with any degree of certainty as to when a Ka-band system will be implemented. The costs used for 1990 were those as given by NASA. What the costs will be in 2000 depends on many factors some of them being:

a. The first implementation of Ka-band systems and acceptance of performance by the user community

b. The technological advancements in Ka-band, which again depends on the need and the vigor with which development is pursued.

Because of the uncertainty and inability to look into the future for some sytem which does not exist, it is assumed that the satellite cost will remain the same.

Projected cost reduction factors for earth stations are indicated here:

Cost Element	Cost Reduction Factor		
	1982	1990	2000
RF	1	0.78	0.54
TDMA Sub System	1	0.27	.094
M&C Sub System	1	0.27	.094

Using these reduction factors, the costs of trunking earth stations are projected to years 1990 and 2000 for C-, Ku- and Ka-bands in Table E-36.

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E.6 TRUNKING NETWORK COSTS AND CROSSOVER DISTANCES WITH TERRESTRIAL TARIFFS (1990 AND 2000)

The methodology used for deriving the trunking network costs, annual payoff requirements, etc., is the same as used in Section 4. The network assumptions for C-, Ku- and Ka-band trunking networks are, again, the same as used in Section 4. It is also assumed that, in the future, digital systems will be used.

E.6.1 C-band Trunking Network Costs (TDMA)

The various cost components for the year 1990 are as follows:

COMPONENT	COST
Earth Station	$ 1,002,000
Earth Segment (for 10 Trunking Earth Stations)	$ 10,020,000
Annual Earth Segment (based on 10-year depreciation)	$ 4,110,000
Annual Space Segment	11,400,000
Annual Central Network Control Facility	200,000
Total Annual Payoff Requirement	$ 15,710,000

Note that this includes neither the channel dependent costs such as channel units nor the terrestrial segment costs.

The cost components for the year 2000 are:

COMPONENT	COST
Earth Station	$ 627,800
Earth Segment (for 10 Trunking Earth Stations)	$ 6,278,000
Annual Earth Segment (based on 10-year depreciation)	$ 2,600,000
Annual Space Segment	11,400,000
Annual Central Network Control Facility	200,000
Total Annual Payoff Requirement	$ 14,200,000

E.6.2 Ku-band Trunking Network Costs (TDMA)

Using the results of Section 5, the various cost components are as follows:

COMPONENT	1990	2000
Earth Station (for 10 Trunking Earth Stations)	$ 8,420,000	$ 5,500,000
Annual Payoff Costs:		
Earth Segment Payoff (based on 10-year depreciation)	$ 3,450,000	$ 2,250,000
Space Segment	16,200,000	7,500,000
Central Network Control Facility	205,000	200,000
Annual Revenue Requirement	$ 19,855,000	$ 9,950,000

E.6.3 Ka-band Trunking Network Costs

The network architecture is assumed to be the same as in 1990. Using a quantity discount, the cost of a single 512 Mbps Earth Station is $3,071,000.

COMPONENT	2000
Earth Station (for 18 Trunking Earth Stations)	$ 55,300,000
Annual Payoff Costs:	
Earth Segment Payoff (based on 10-year depreciation)	$ 22,662,000
Space Segment (for one full Ka-band Trunking Sateilite	101,760,000
Central Network Control Facility	615,000
Total Annual Payoff Requirement	$125,037,000

Table-37 summarizes the projected annual recurring costs for the trunking networks for C-, Ka-, and Ku-band satellite systems for the years 1990 and 2000.

E.6.4 Terrestrial Tariffs

In Section 4, the 1982 satellites based on end-to-end user costs were compared to terrestrial tariffs. For obtaining an estimate of crossover distances for various services, the terrestrial tariffs are projected to the years 1990 and 2000. In projecting the terrestrial tariffs, the following factors are taken into account:

a. Past history of terrestrial tariffs.
b. Technological advancements.
c. Divestiture of Bell Operating Companies (BOCs) from AT&T Long Lines.

Historical data reveals that prices of communciations services have increased much less rapidly than all consumer spending over the last 17 years. This is due to the competitive pressure exerted by the entry of specialized common carriers since 1970, and the rapid advancements in digital technology and integrated circuitry.

It is hard to estimate how the divestiture of BOCs from AT&T's Long Lines will impact the tariffs; but it is a generally accepted fact in the communications industry that Long Lines tariffs should come down and local tariffs go much higher.

For this study, it is assumed that between 1982 and 1990, the central office-to-central office (long haul) tariffs will be reduced by 12%, where the termination charges will be reduced 20%. Between 1990 and 2000, the long haul tariffs will decline by 7%, whereas termination charges will be reduced 15%. The reduction factors used for terrestrial tariffs appear below:

	REDUCTION FACTORS		
	1982	1990	2000
Long Haul Tariff	1.00	.88	.82
Digital Termination	1.00	.80	.68

It is assumed that the tariff structure will remain the same in 1990 and 2000 as it is in 1982.

E.6.5 Crossover Distances

Using Table E-37, the end-to-end user costs for various services were computed and compared with 1990 and 2000 terrestrial tariffs as projected in Section 6.4. Computer algorithms were written to compute the crossover distances. The crossover distances for trunking terminals for the years 1982, 1990 and 2000 are summarized in Table E-38. Note that only the TDMA approach has been considered, consistent with the assumptions made in Section 5.

WESTAR IV - VI REPEATER BLOCK DIAGRAM

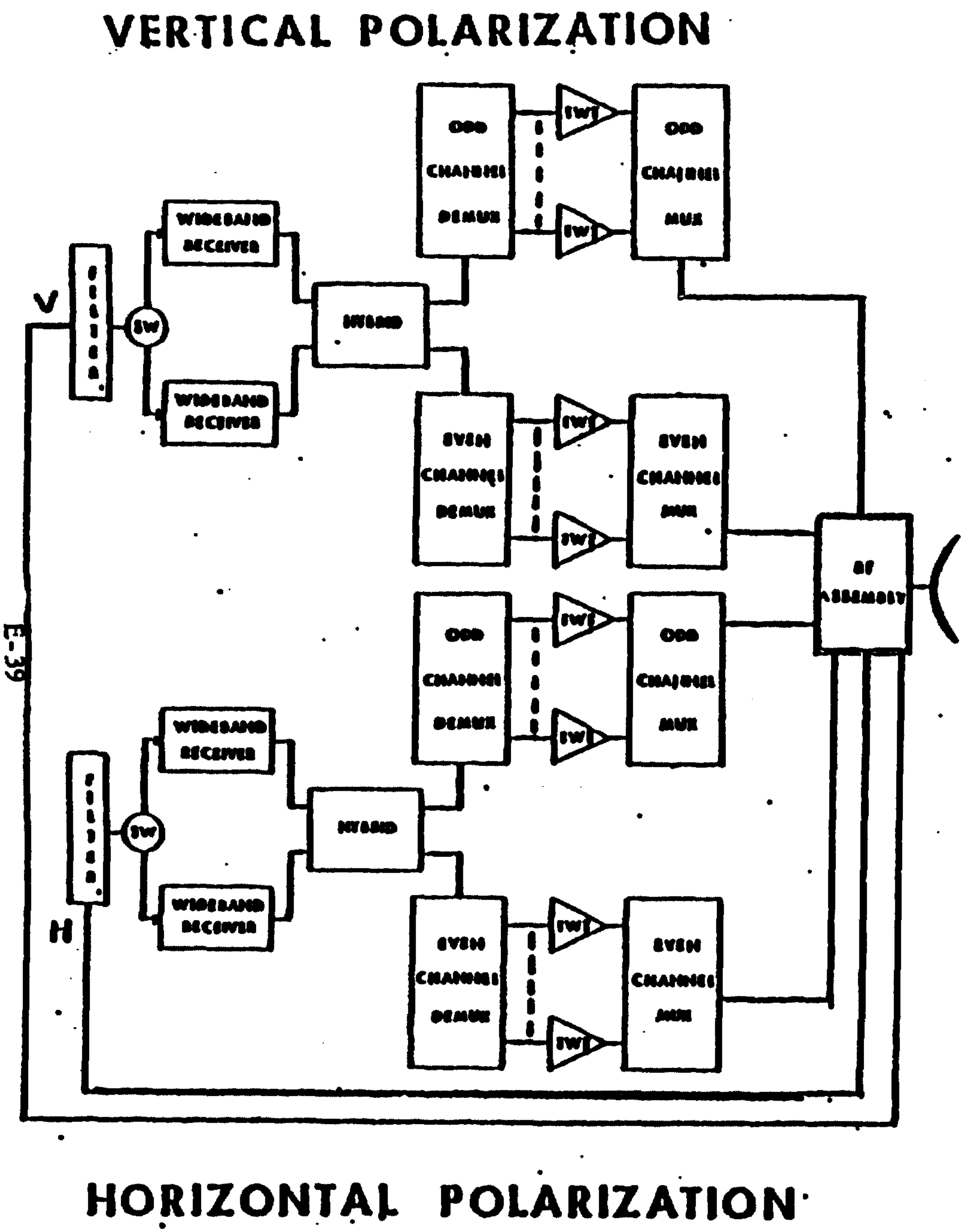

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FIGURE E-1.

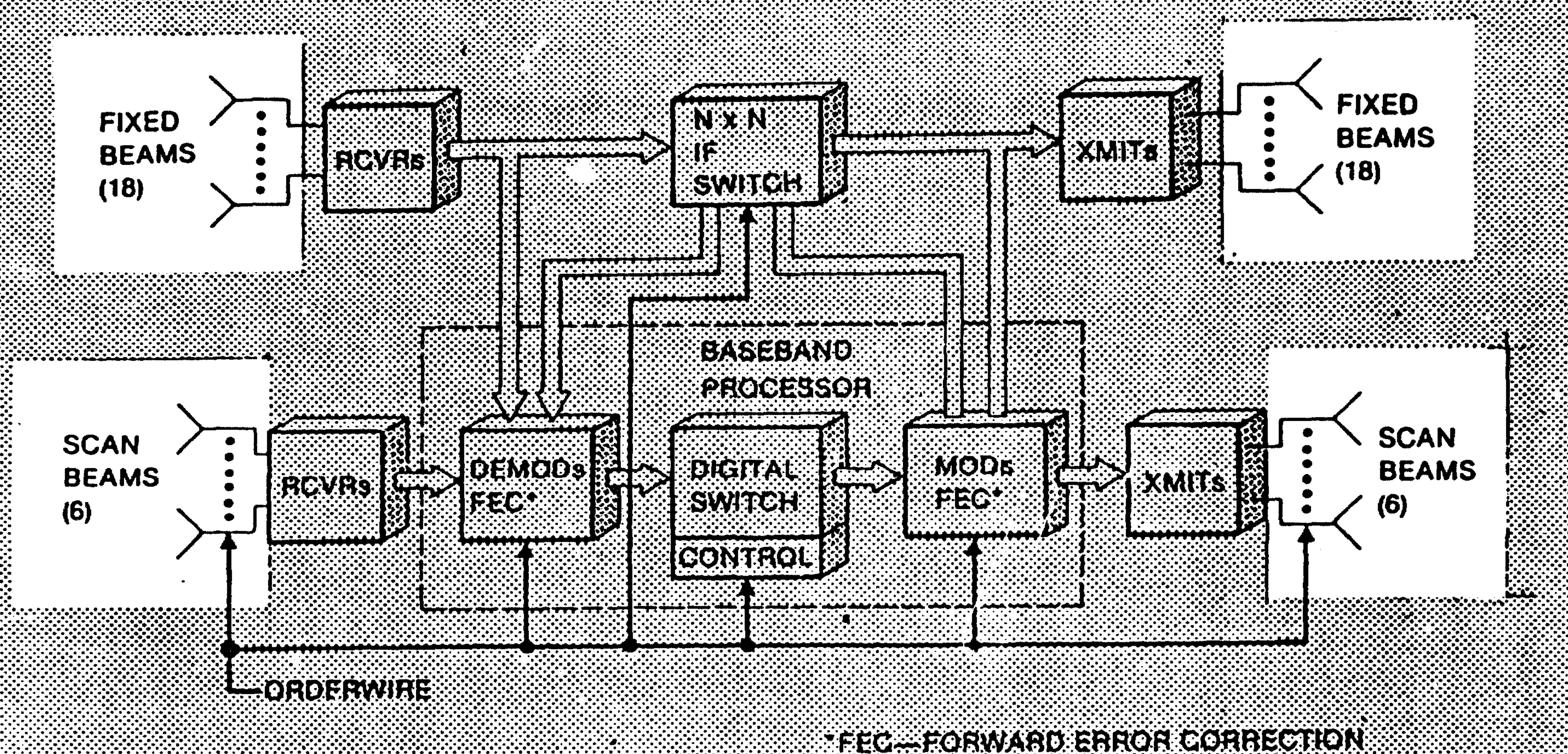
FIXED
BEAMS
(18)
RCVRs
N x N
IF
SWITCH
XMITs
FIXED
BEAMS
(18)
BASEBAND
PROCESSOR
SCAN
BEAMS
(6)
RCVRs
DEMODs
FEC*
DIGITAL
SWITCH
CONTROL
MODs
FEC*
XMITs
SCAN
BEAMS
(6)
ORDERWIRE
*FEC—FORWARD ERROR CORRECTION

FIGURE E-2.

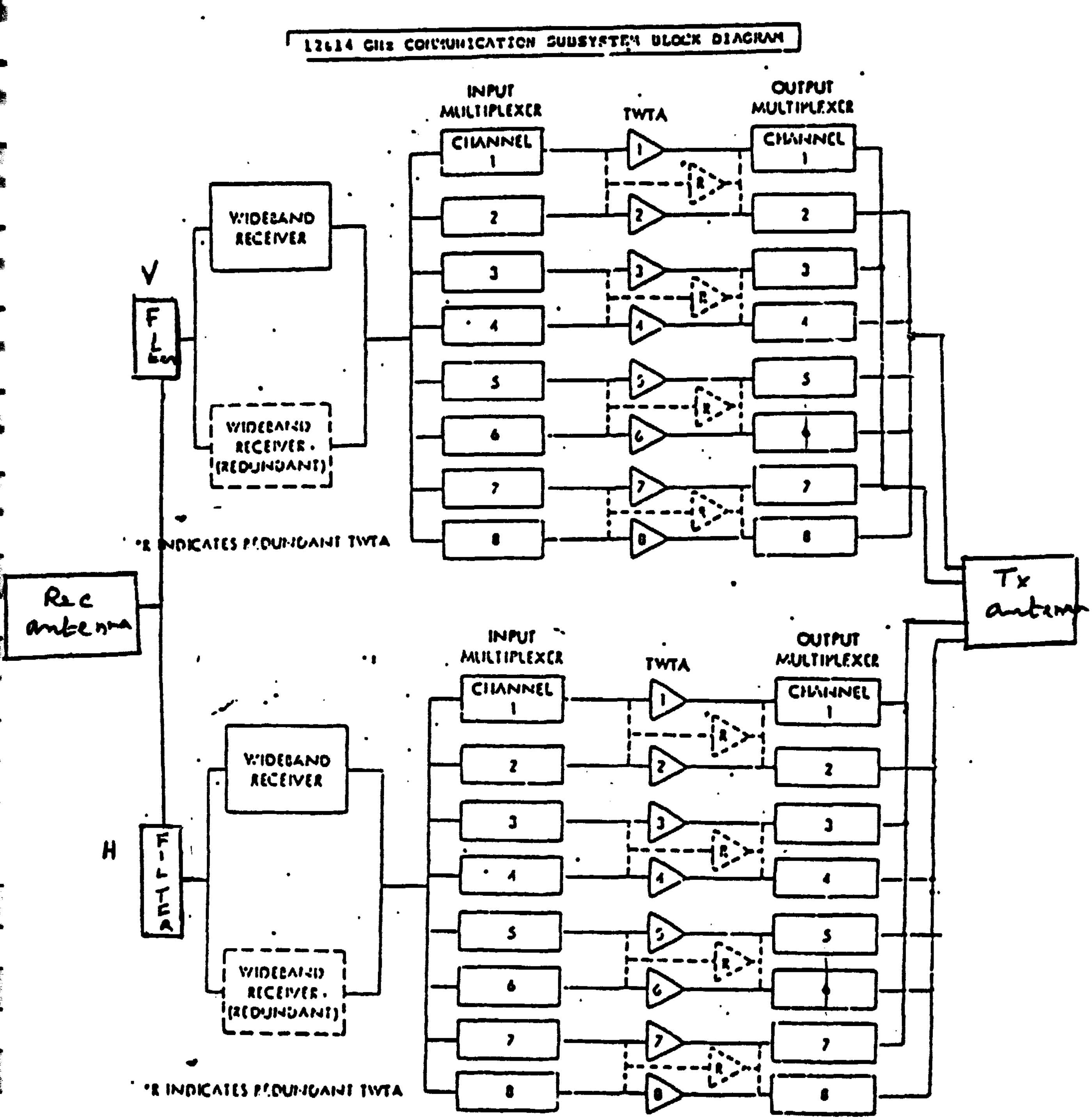
12&14 GHz COMMUNICATION SUBSYSTEM BLOCK DIAGRAM
INPUT MULTIPLEXER
TWTA
OUTPUT MULTIPLEXER
CHANNEL 1
2
3
4
5
6
7
8
WIDEBAND RECEIVER
WIDEBAND RECEIVER (REDUNDANT)
V
FILTER
H
Rec antenna
Tx antenna
*R INDICATES REDUNDANT TWTA

FIGURE E-3

SPACE SEGMENT COST	+	ALL LOADINGS AND PROFITS FOR N YEARS	÷	AVERAGE NUMBER OF TRANSPONDERS IN USE	=	TOTAL AVERAGE PER TRANSPONDER PAY BACK	YEARLY AVERAGE PAY BACK
201 Million	N* 8	313 M		36		14.5 M	1.81 M
1 Million /Year	10	402.2 M		36		17 M	1.7 M

N* = The life of the satellite

FIGURE E-4. C BAND

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SPACE SEGMENT COST	+	ALL LOADINGS AND PROFITS FOR N YEARS	÷	AVERAGE NUMBER OF TRANSPONDERS IN USE	=	TOTAL AVERAGE PER TRANSPONDER PAY BACK	YEARLY AVERAGE PAY BACK
248.5 M 1 M/Year	N* 8	398.4		24		27.5 M	3.43 M
	10	511 M		24		32.1 M	3.21 M

N* = The life of the satellite

FIGURE E-5. KU BAND

SPACE SEGMENT COST	+	N*	ALL LOADINGS AND PROFITS FOR N YEARS	÷	AVERAGE NUMBER OF TRANSPONDERS IN USE	=	TOTAL AVERAGE PER TRANSPONDER PAY BACK	YEARLY AVERAGE PAY BACK
326 + 2 M/Year		8	541.2		40		22.2	2.8
		10	670		40		25.4	2.54

N* = The life of the satellite

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FIGURE E-6. KA BAND TRUNKING EQUIVALENT TRANSPONDER COST

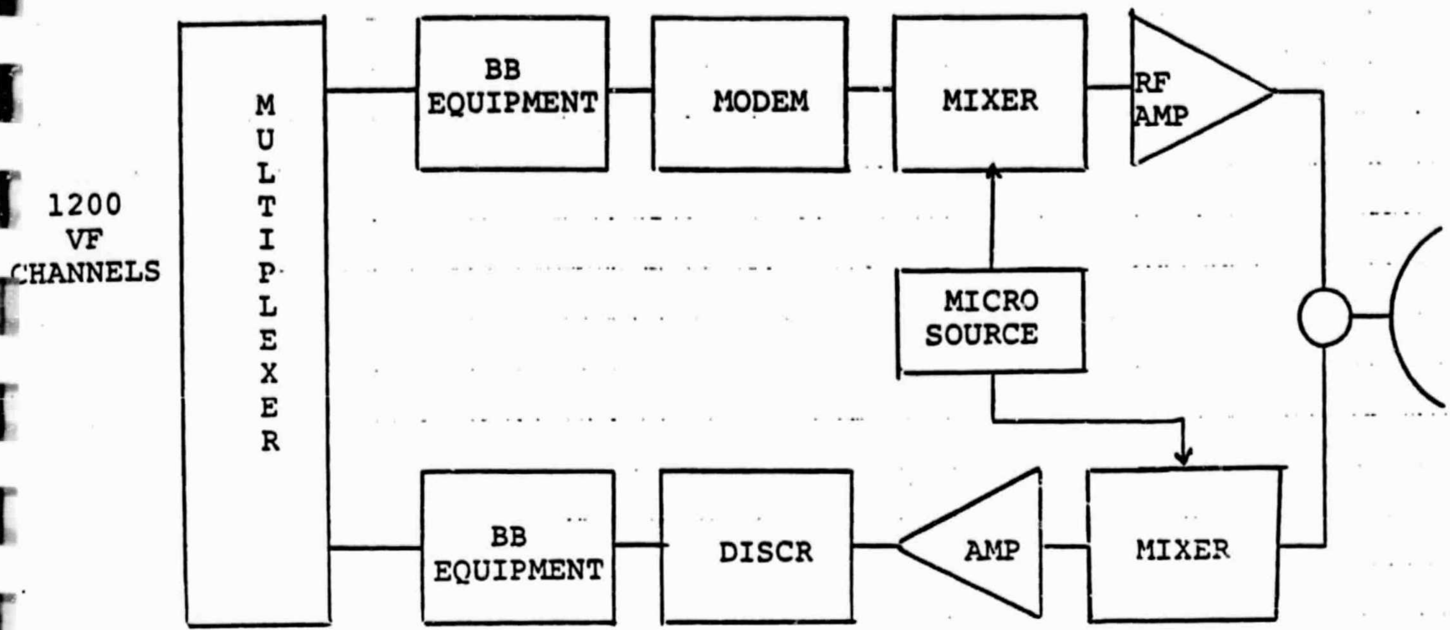


FIGURE E-7a. BLOCK DIAGRAM OF ANALOG RADIO TERMINAL

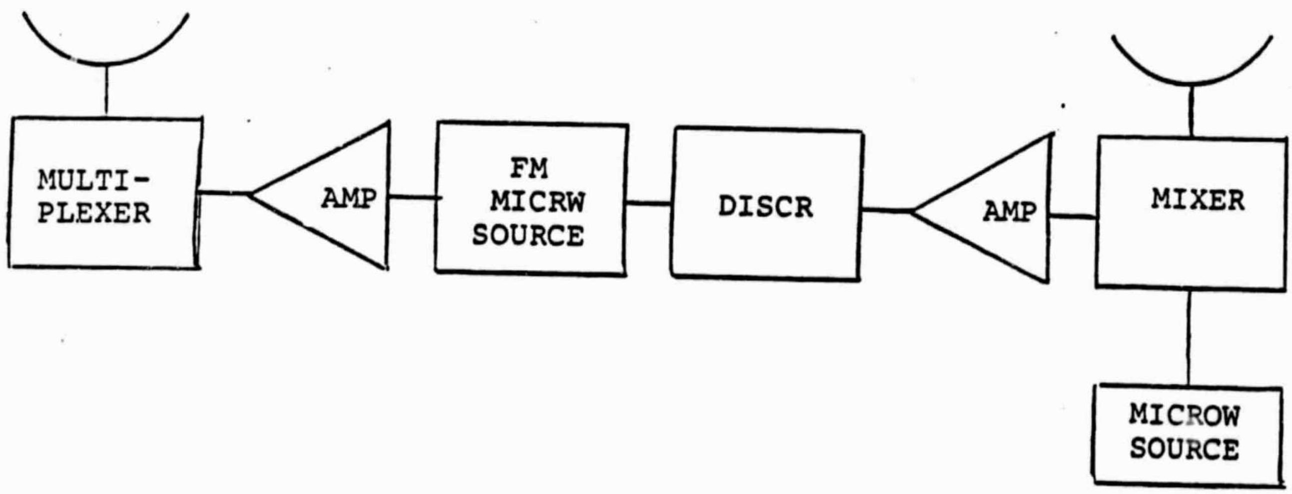


FIGURE E-7b. BLOCK DIAGRAM OF ANALOG RADIO REPEATER

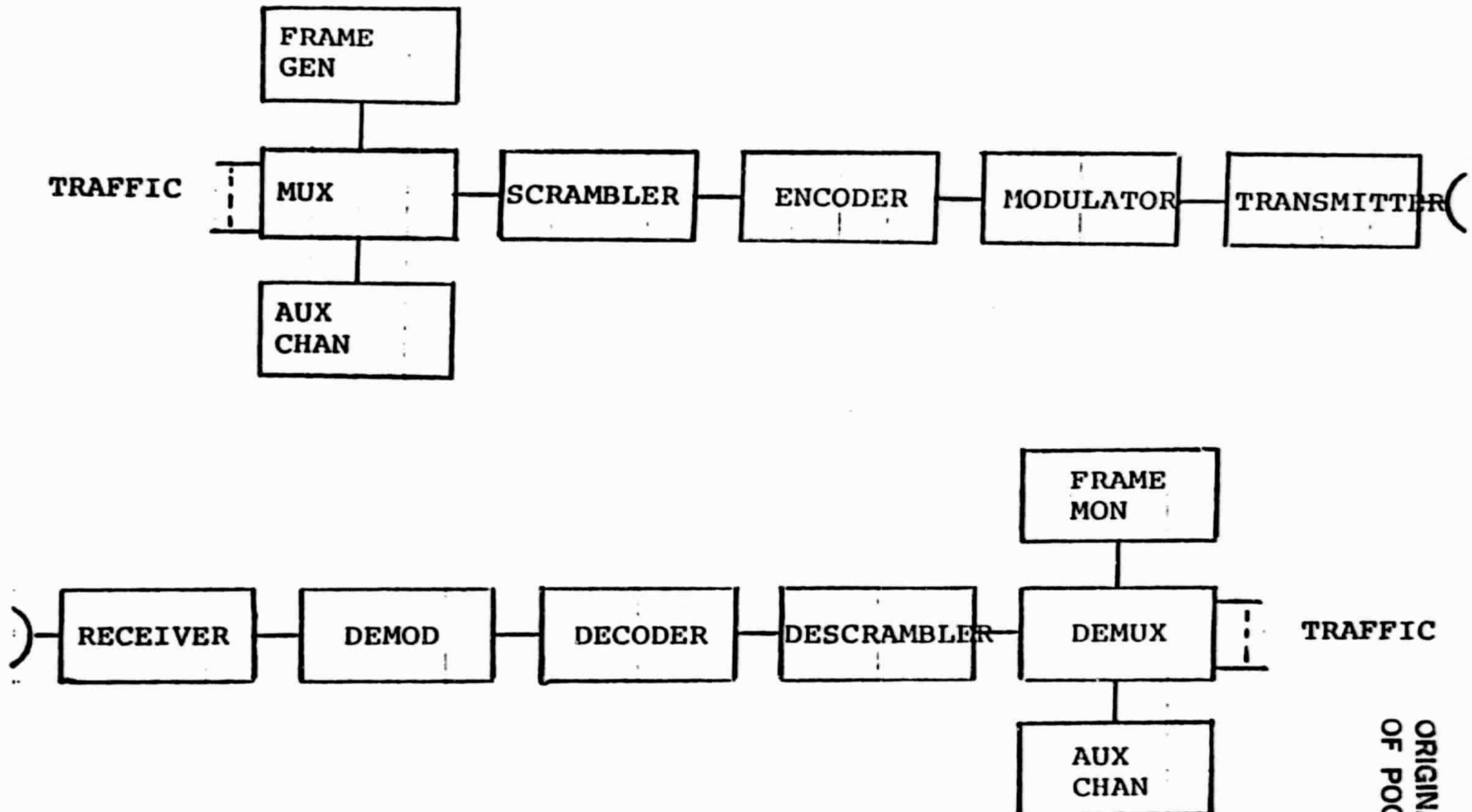
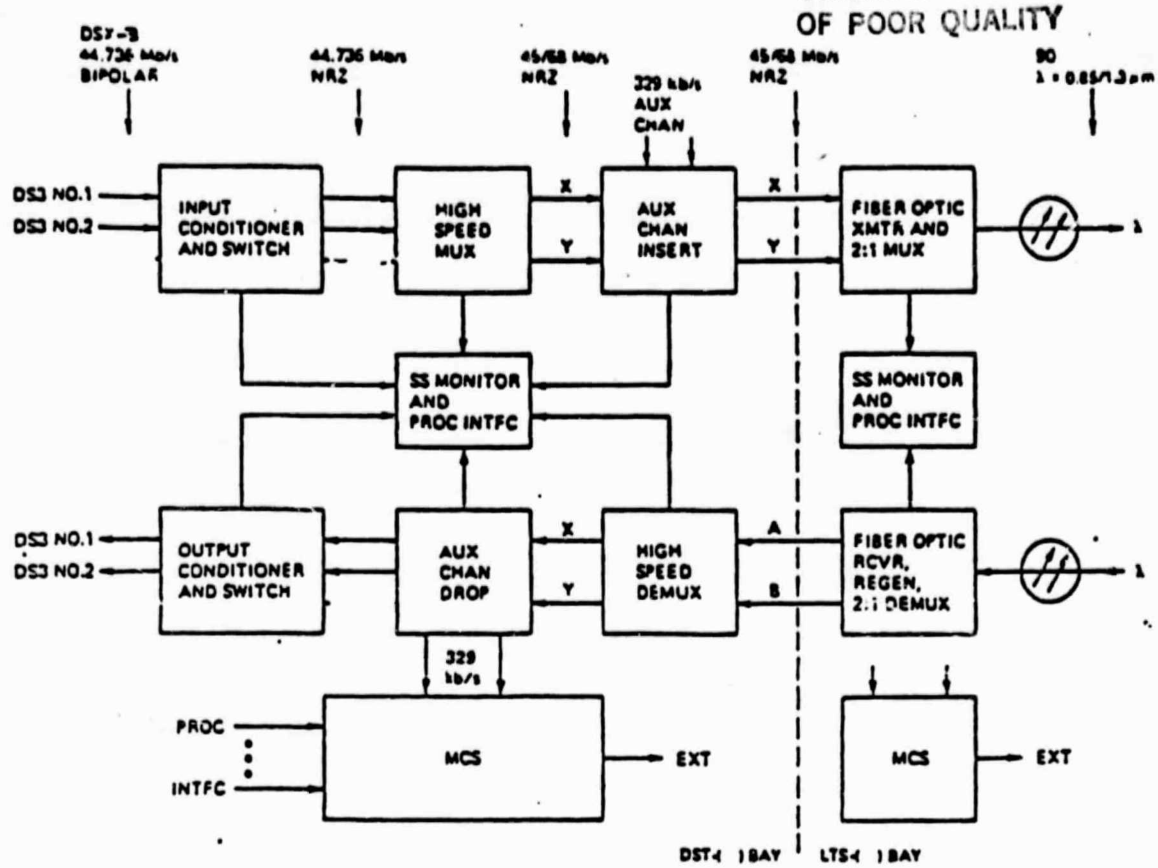
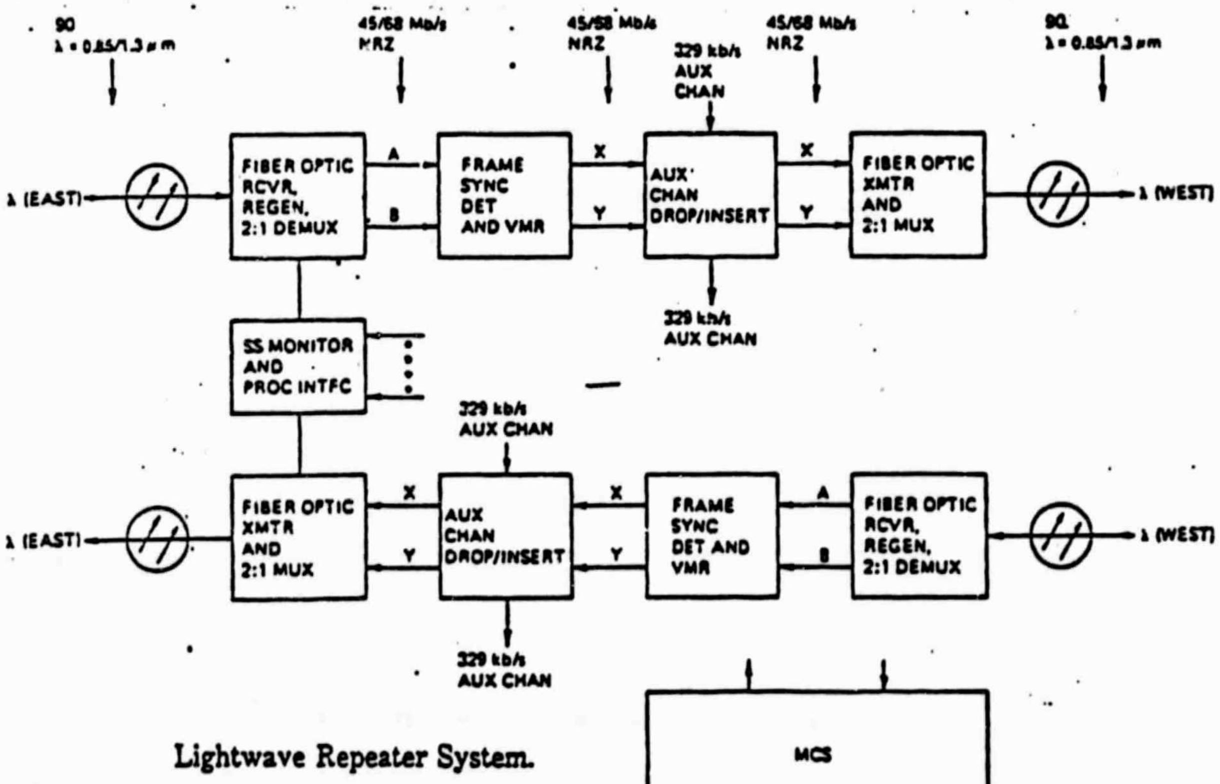


FIGURE E-8. DIGITAL RADIO BLOCK DIAGRAM



Lightwave Terminal System.



Lightwave Repeater System.

FIGURE E-9. FIBER OPTIC SYSTEM

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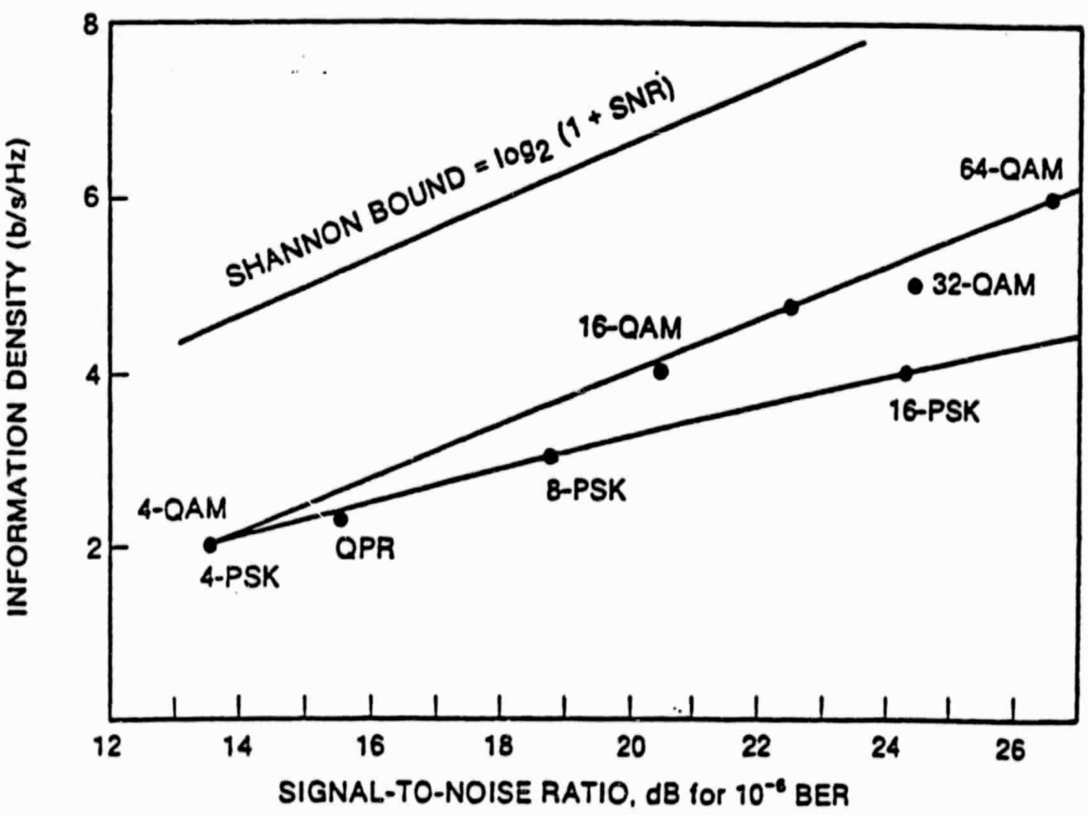

FIGURE E-10. CHANNEL CAPACITY FOR VARIOUS MODULATION SCHEMES

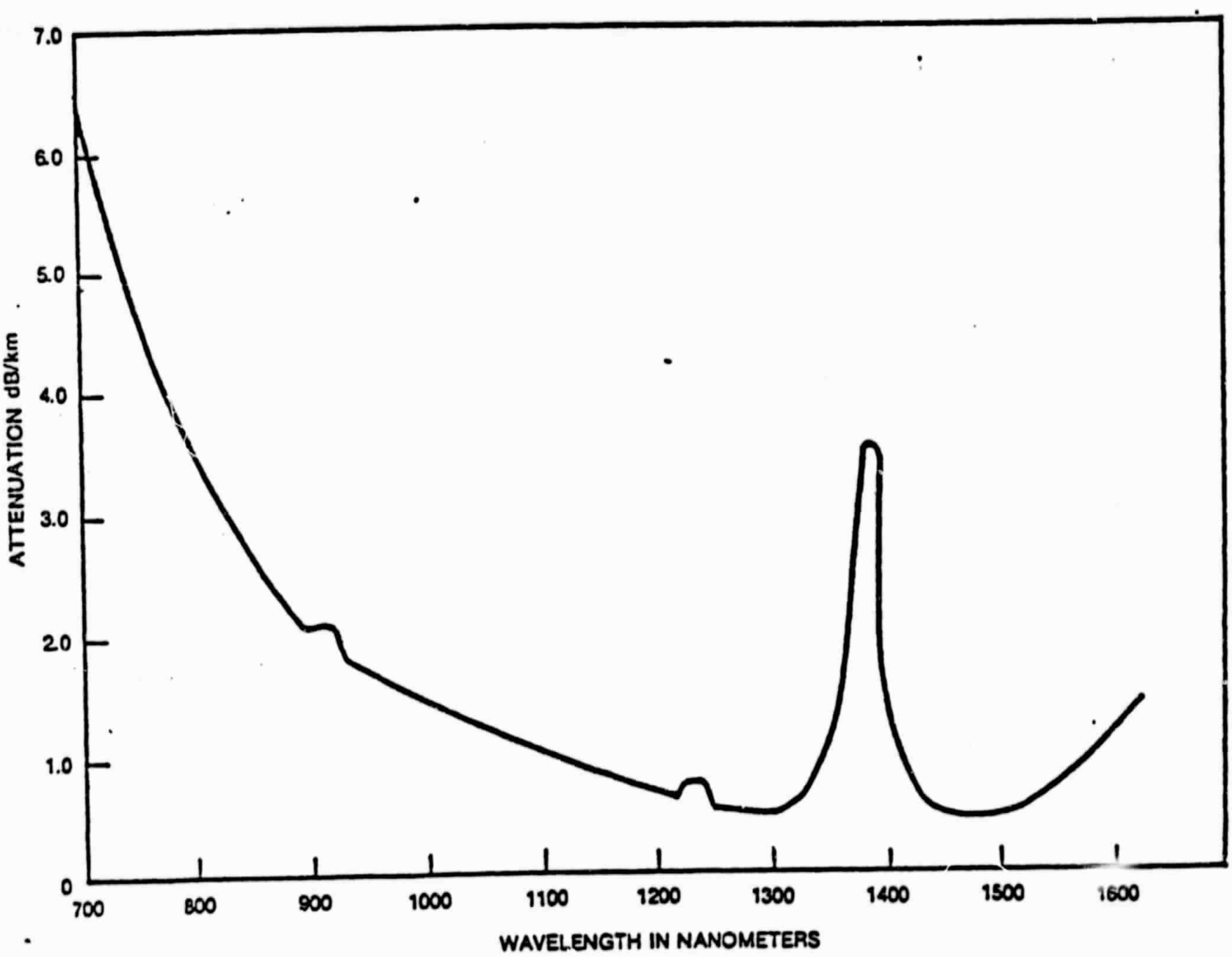

FIGURE E-11. ATTENUATION VERSUS WAVELENGTH CHARACTERISTIC OF OPTICAL FIBER

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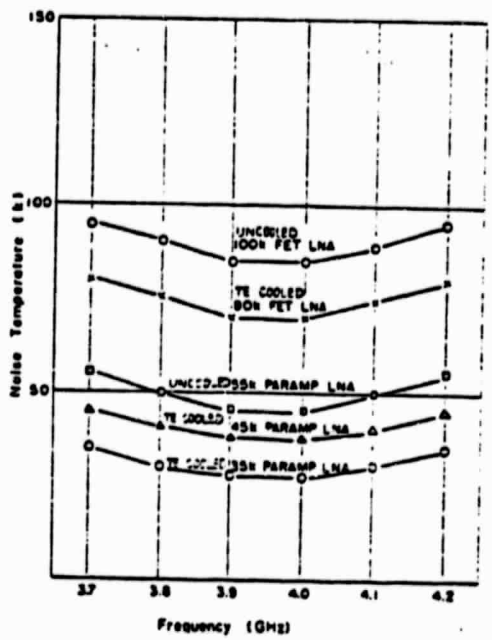

FIGURE E-12. TYPICAL NOISE TEMPERATURE OF 4 GHz LNA

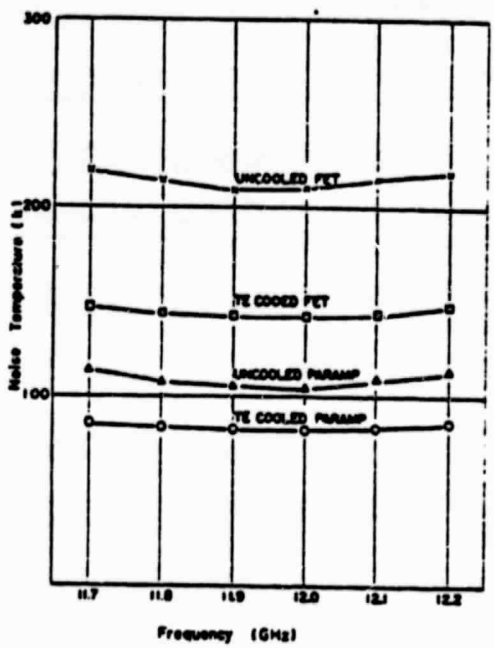

FIGURE E-13. TYPICAL NOISE TEMPERATURE OF 12 GHz LNA

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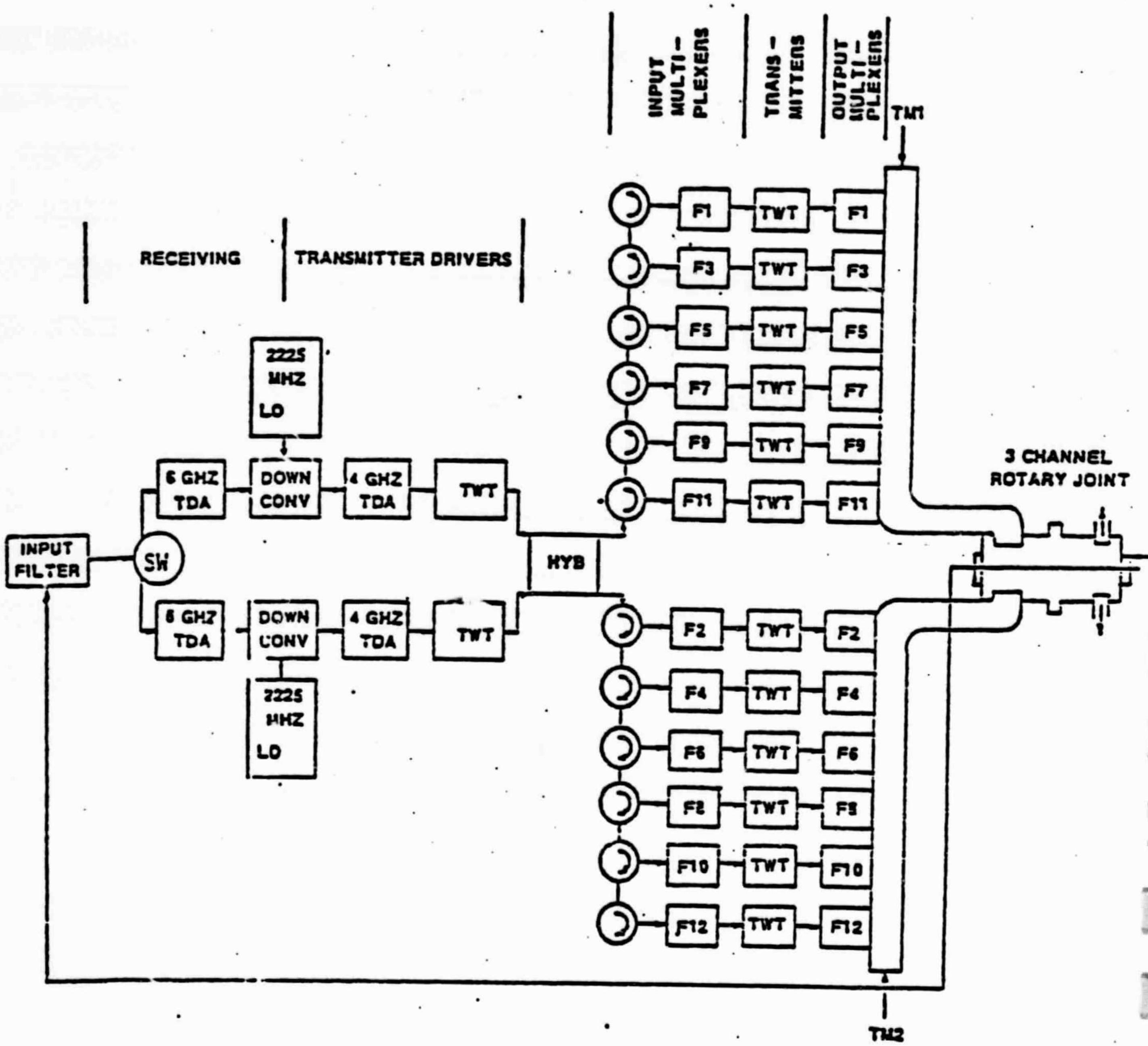

FIGURE E-14. REPEATER BLOCK DIAGRAM

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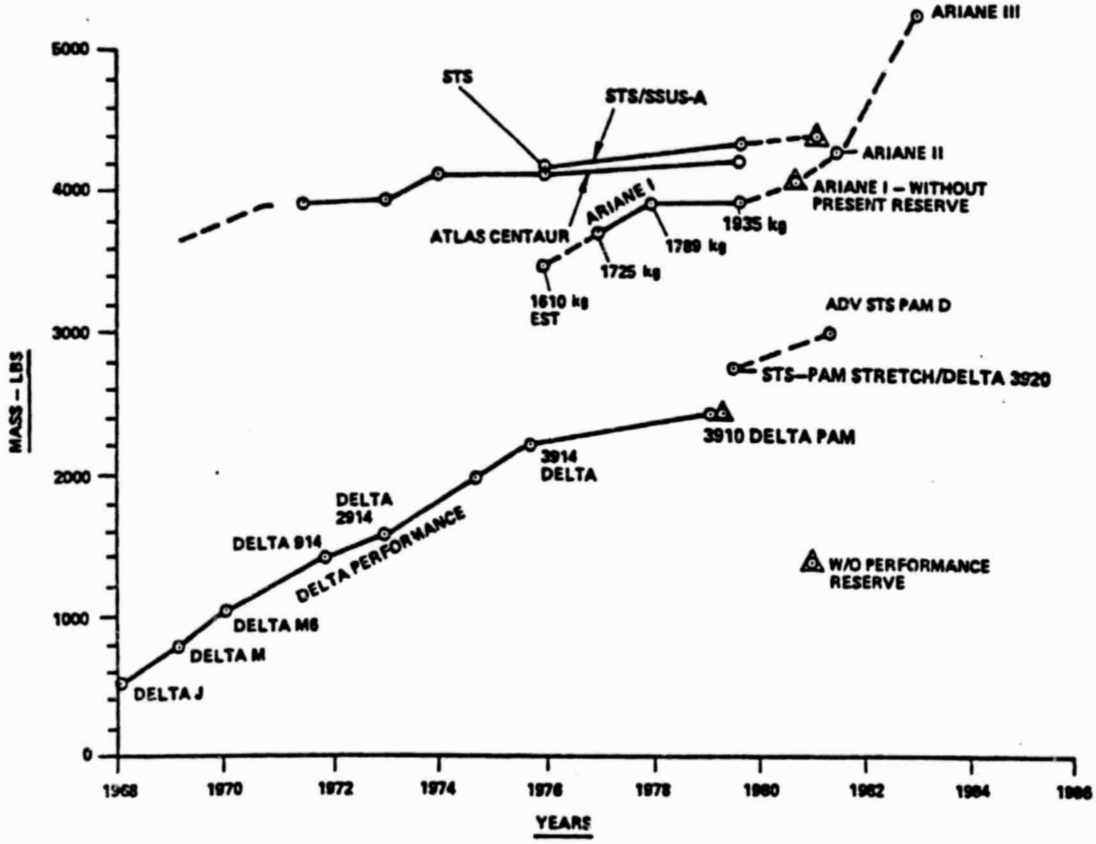

FIGURE E-15. INCREASE IN LAUNCH VEHICLE CAPABILITY
(WEIGHT IN TRANSFER ORBIT)

TABLE E-1. C-BAND ANTENNA COSTS
(in thousands of dollars)

DIAMETER:	4m	5m	7m	10m	11m	12m
COST:	2.5*	7*	33*	125	182	225

* Does not include frequency reuse.

NOTE: 10, 11 and 12 meter antenna costs include the cost of the antenna, tracking and frequency reuse.

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TABLE E-2. C-BAND LOW NOISE AMPLIFIER COSTS
(in thousands of dollars)

	40°	50°	80°	90°	120°
NON-REDUNDANT	24	17	9	10	8
REDUNDANT	52	38	22	24	20

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TABLE E-3. C-BAND TWT POWER AMPLIFIER COSTS
(in thousands of dollars)

POWER OUTPUT (Watts)	5	10	20	25	40	75	125	400	600	700	1kw	3kw
NON-REDUNDANT	2		7	10	11	16	21.5	29	36	39	82	200
REDUNDANT UNIT	10		23	29	31	41	52	67	81	87	174	420

C-BAND KLYSTRON COSTS
(in thousands of dollars)

POWER OUTPUT (Kwatts)	3	3.3
NON-REDUNDANT	47.5	55.0
REDUNDANT	104.5	119.5

TABLE E-4. C-BAND FREQUENCY CONVERTER COSTS
(in thousands of dollars)

TYPE OF CONVERTER:	UPCONVERTER	DOWNCONVERTER
NON-REDUNDANT	9.1	8.8
REDUNDANT	19.6	19.0

TABLE E-5. COST OF TDMA TERMINALS (INCLUDING MODEMS)
(in thousands of dollars)

BURST RATE	60 Mbps	15 Mbps	8 Mbps
NON-REDUNDANT	140	50	40
REDUNDANT	240	80	58

TABLE E-6. C-BAND 60MHZ LINK BUDGET SUMMARY

UNITS	ITEM	UPLINK (6 GHz)	DOWNLINK (4 GHz)
dbw	Saturation EIRP	82.4	32
db	Five Space Loss	199.6	196.1
db	Atmospheric and Rain Margin	4	4
db/^{o}k	G/T	-7	32.1*
	Boltzman Constant	228.6	228.6
	Info Bit Rate (60 Mbps)	78	78
	Channel Eb/No	29.4	14.6

Available System Eb/No = 14.5

Required Eb/No for 10^{-7} BER = 13 db

Margins in Eb/No = 1.5 db

HPA Requirement = EIRP - antenna gain + losses + line

= 31.4

= 2 kw trunk

* For G/T of 32.1 an 11 meter antenna and a 50^o k LNA is required.

TABLE E-7. COST OF 60 MBPS TDMA C-BAND EARTH STATION
(in thousands of dollars)

ITEM	COST
11 meter antenna	182.5
50° LNA	47.4
Uplink Subsystem (3 KW HPA and U/C)	146.7
TDMA Subsystem	38.8
Monitor and Control Subsystem	33.0
Transponder Hopping	20.0
Total Earth Station Cost	709.0
Installation and Integration (40% of Earth Station Cost)	284.0
TOTAL COST	993.0

TABLE E-8. FM SYSTEM TX PARAMETERS

n	1200
Fm	5.04
F	12.96
g	6.16
Fc	665.7
$10 \log \frac{B}{b}$	40.6
$20 \log \frac{Fch}{Fm}$	-17.6
$\frac{S}{N}$	50.0
PDI	4.0
W	2.5
$(\frac{C}{N})$	20.5
m	2.57

C-BAND 1200 VF FDM/FDMA LINK BUDGET SUMMARY

	UPLINK	DOWNLINK
Saturation EIRP	82.4	34.0
Path Loss	199.6	196.1
$\frac{C}{N}$	25.8	22.0

$(\frac{C}{N})$ system = 20.5

TABLE E-9. COST OF 1200 VF - FDM/FM C-BAND EARTH STATION
(in thousands of dollars)

ITEM	COST
12 Meter Antenna	225.0
40^{o} LNA	52.0
Uplink Subsystem: (600 Watt HPA, Double Conversion U/C FM (Modulator, Patch Panels, Equalizers, etc.)	151.0
Downlink Subsystem: (Double Conversion Down Converter, FM Demodulator, etc.)	45.4
Monitor and Control Subsystem	33.0
FDM/FDMA Earth Station Cost	506.5
Installation and Integration Cost (40% of Earth Station Cost)	202.6
TOTAL COST	709.1

TABLE E-10. KU-BAND ANTENNA COSTS
(in thousands of dollars)

ANTENNA DIAMETER:	5.5	7.7	10
COST	60	125	153
FREQUENCY REUSE	15	15	15

NOTE: Antennas with diameters greater than or equal to 7.7 meters include the cost of antenna tracking.

TABLE E-11. KU-BAND LOW NOISE AMPLIFIER COSTS
(in thousands of dollars)

	125°K
NON-REDUNDANT	21
REDUNDANT	50

TABLE E-12. KU-BAND HPA COSTS
(in thousands of dollars)

Power Watts	25	40	75	125	200	300	400	600	1000	2000
Non-redundant	20			31.5	38	40	45	65	140	220
Redundant	50			73	86	90	102	142	298	558

TABLE E-13. FREQUENCY CONVERTER COSTS
(in thousands of dollars)

C-BAND	UPCONVERTER	DOWNCONVERTER
NON-REDUNDANT	14.5	14.5
REDUNDANT	31.5	31.5

TABLE E-14. KU-BAND 60 MBPS LINK BUDGET SUMMARY

ITEM	UPLINK		DOWNLINK	
EIRP in dbw	79.5	dbw	43.4	dbw
Total Path Loss	207.5	db	205.9	db
Tracking Loss	-1.2	db	-0.8	db
G/T	1.6	db/k	33.8	db/k
Boltzman Constant	228.6	dbw/^{o}k-hz	228.6	dbw/^{o}k-hz
Info Bit Rate (60 Mbps)	78.0		78.0	
Rain Margin	7.0		7.0	db
Channel Eb/No	16.0		14.1	

Available System Eb/No = 12 db

Required Eb/No for 10^{-6} BER is 10.8

Margin Eb/No is 1.2 db

HPA = EIRP - antenna gain + Losses + Linearity

= 79.5 - 58.4 + 1.5 + 3

= 4-- watt

For G/T of 33.8 db/^{o}k a 7.7 meter antenna with 125^o LNA

TABLE E-15. COST OF 60 MBPS TDMA KU-BAND EARTH STATION
(in thousands of dollars)

ITEM	COST
7.7 Meter Antenna	125.0
Uplink Subsystem	156.0
Downlink Subsystem	38.8
TDMA Subsystem	240.0
Monitor and Control Subsystem	33.0
125° LNA	50.0
TDMA Earth Station Cost	642.8
Installation and Integration Cost (40% of Earth Station Cost)	257.1
TOTAL COST	900.0

TABLE E-16A. FM SYSTEM TX PARAMETERS
FM 1500 CHANNEL

Fm	6.3	Mbps
F	20.7	
g	6.88	
L	3.61	
Fch	952.12	KHz
$10 \log \frac{B}{b}$	42.4	
$20 \log \frac{Fch}{Fm}$	-16.4	
$\frac{S}{N}$	50.0	
PDI	40.0	
W	2.5	
$(\frac{C}{N})$ req	17.5	

TABLE E-16B. GSAT BUDGET FOR FDM/FDMA
1500 CHANNELS

Downlink		
	Satellite EIRP	43.4 dBw
	Path Loss	206.0
	G/T	33.8
	Boltzman Constant	228.6
	10 log B	77.32
	$(\frac{C}{N})$ D	22.48
Uplink		
	Saturation Flex Density	-82.0
	Beam Spreading Loss	162.5
	ES EIRP at Saturation	81.5
	Uplink Path Loss	207.5
	Spacecraft G/T	+1.6
	Boltzman Constant	228.6
	10 log B	77.32
	$(\frac{C}{N})$ up	26.88
	$(\frac{C}{N})$ u + D	21.1
	Req $\frac{C}{N}$	17.5
	Margin	3.63

HPA = EIRP - Antenna Gain + Losses + Linearity
= 81.5 - 58.4 + 1.5 = 24.6
= 400 Watts

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TABLE E-17. COST FOR KU-BAND FDM/FDMA EARTH STATION WITH 1500 VF CHANNELS
(in thousands of dollars)

ITEM	COST
7.7 Meter Antenna	125.0
Uplink Subsystem: (U/C, 400-Watt, FM modulator)	176.0
Downlink Subsystem: (FM demodulator)	45.5
125° LNA	52.0
Monitor and Control Subsystem	33.0
FDM/FDMA Earth Station Cost	429.5
Installation and Integration Cost (40% of Earth Station Cost)	171.8
TOTAL COST	601.5

TABLE E-18A. COST FOR KA-BAND TRUNKING TERMINALS IN YEAR 1990 (1982 DOLLARS)

	PRIMARY	DIVERSITY
5 Meter Antenna	380,000	380,000
500-Watt Redundant HPA	420,000	420,000
Redundant Upconverter	70,000	70,000
LNA	90,000	90,000
Downconverter	70,000	70,000
512 Mbps Burst Modem	110,000	-0-
Buffer Mux/Demux	220,000	-0-
Burst Synchronizer and Acquisition Unit	20,000	-0-
Hardware and Calling	20,000	20,000
Subtotal	1,600,000	1,050,000
Installation and Testing (at 17%)	272,000	179,000
Management and Engineering (at 44%)	708,000	-0-
Spare Parts	90,000	-0-
Subtotal	2,676,000	1,229,500
Diversity and Link Switch	1,000,000	
TOTAL	4,905,000	

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TABLE E-18B. WU ESTIMATE
COST ESTIMATES IN THOUSANDS OF DOLLARS
FOR KA-BAND TRUNKING TERMINAL

BURST RATE = 512 MBPS

COST BREAKDOWN FOR TRUNKING TERMINAL USING TDMA

	PRIMARY	DIVERSITY
5 Meter Antenna	25	25
Redundant HPA (150-watt)	100	100
LNA	60	60
Up and Downconverter	60K	60K
TDMA	500	---
M&C	100	---
TOTAL	845	245
Installation and Integration	423	123
TOTAL	1268	368
Diversity Link	1.0 million	
TOTAL	2836.00	

TABLE E-19. COST OF TRUNKING EARTH STATIONS
(in thousands of dollars)

BAND	APPROACH	UPLINK BURST RATE	DOWNLINK BURST RATE	CAPACITY	EARTH STATION COST	INTEGRATION COST	TOTAL
C-Band	TDM	60 MBPS	60 MBPS	Anywhere up to 60 MBPS	709	284	993
C-Band	FDM/FM	N/A	N/A	Up to 1200 VF Channels	506	202.6	709.1
Ku-Band	TDM	60 MBPS	60 MBPS	Anywhere up to 60 MBPS	642.8	257.23	900
K-Band	FDM/FM	N/A	N/A	Up to 1500 VF Channels	429.5	171.8	601.5

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TABLE E-20. PRIMARY OPERATIONAL SATELLITE CHARACTERISTICS

PARAMETER	TYPE OR VALUE
Launch vehicle	Delta 3910/PAM
Satellite mission life/design life	8.5 years, minimum/10 years
North-south stationkeeping accuracy	$\pm 0.1^{\circ}$
East-west stationkeeping accuracy	$\pm 0.1^{\circ}$
Eclipse capability	100% (24 channels)
Stabilization	Spin stabilized
RF output power per TWTA	8 watts
Communications channelization	24 operational 36 MHz transponder channels
Communications EIRP per transponder	CONUS: 34 dBW
Communication receive G/T	CONUS: -7.2 dB/K
6/4 Communications frequencies	
Transmit	3.7 to 4.2 GHz
Receive	5.925 to 6.425 GHz
TT&C EIRP	7.9 dBW, reflector antenna 5.0 dBW, bicone antenna
TT&C receive G/T	-23.3 dB/K, reflector antenna -43.4 dB/K, bicone antenna, worst case
TT&C frequencies	
Telemetry	4198 MHz
Command	5.923 to 5.930 GHz, transfer orbit 6.420 to 6.425 GHz, on-station
Communications polarization	
Transmit	12 channel linear horizontal, 12 channel linear vertical
Receive	12 channel linear vertical, 12 channel linear horizontal
TT&C polarization	
Telemetry	Transfer orbit vertical On-station, horizontal
Command	Transfer orbit horizontal On-station, vertical

TABLE E-21. REPRESENTATIVE SPACECRAFT WEIGHT BUDGET

SUBSYSTEM IDENTIFICATION	WEIGHT, LB
Launch vehicle (Delta 3910/PAM) payload	2380
AKM consumables	1076
Hydrazine (includes 8.5 year stationkeeping)	274
Dry satellite	1030
Communications (includes antenna)	256
Reaction control (dry)	29
Attitude control	52
Thermal control	44
Telemetry, tracking and command	59
AKM case at burnout	64
Structure	200
Electrical power (includes harness)	274
Balance and miscellaneous	12
Contingency	40

TABLE E-22. CHANNEL CENTER FREQUENCY ASSIGNMENTS

EARTH-TO-SPACE		SPACE-TO-EARTH	
Assigned Freq, MHz	Polarization*	Assigned Freq. MHz	Polarization*
5945	V 1	3720	H 1
5965	H 1	3740	V 1
5985	V 2	3760	H 2
6005	H 2	3780	V 2
6025	V 3	3800	H 3
6045	H 3	3820	V 3
6065	V 4	3840	H 4
6085	H 4	3860	V 4
6105	V 5	3880	H 5
6125	H 5	3900	V 5
1645	V 6	3920	H 6
6165	H 6	3940	V 6
6185	V 7	3960	H 7
6205	H 7	3980	V 7
6225	V 8	4000	H 8
6245	H 8	4020	V 8
6265	V 9	4040	H 9
6285	H 9	4060	V 9
6305	V 10	4080	H 10
6325	H 10	4100	V 10
6345	V 11	4120	H 11
6365	H 11	4140	V 11
6385	V 12	4160	H 12
6405	H 12	4180	V 12

*Polarization: H - Horizontal linear; V - Vertical linear

TABLE E-23. PRIMARY OPERATIONAL SATELLITE CHARACTERISTICS

PARAMETER	
Satellite mission life/design life	10 years
North South station keeping accuracy	$\pm$ 0.05
East West station keeping accuracy	$\pm$ 0.05
R F output power per TWTA	20 watt/30 watt
Communication Channelization	16 operational, 54 MHz transponder channels.
Communication EIRP/Transponder	40-47 dbw
Communication Receive c/t	+1.6 db/op
12/14 Communication Frequencies	
Transmit	11.7 - 12.2 GHz
Receive	14 to 14.5 GHz

TABLE E-24. REPRESENTATIVE SPACECRAFT WEIGHT BUDGET

Subsystem Identification	Weight
Total life off weight	2769 lbs.
Communication payload weight	300 lbs.
Bus Subsystem weight	849 lbs.
Total Propellent	290 lbs.
AKM expendables	1295 lbs.
Margin	3611 lbs.

TABLE E-25. 1200 VF ANALOG RADIO COSTS
(in thousands of dollars)

Item	COSTS Earth Station	Repeater	Office Central	Total
Radio equipment	32	50	32	114.0
Fault and Alarm System	9	5.1	9	23.1
Antenna and Waveguide	10	16	10	36.0
Civil Works	22	60	22	104.0
Tower and Building	17	36	17	70.0
Power	11	13	11	35.0
Land and Acquisition	3	24	3	30.0
Field Survey and FCC Coordination	7	7	7	21.0
Test Equipment and Spares	20	11.1	20	51.1
Miscellaneous (Documentation, Training, etc.)	19	9.5	19	47.5
FDM MUX	126	--	678	804.0
Installation	56	31.3	169	256.3
TOTAL	332	263.0	997	1,592.0

TABLE E-26. 90 MBPS DIGITAL RADIO COSTS
(in thousands of dollars)

Item	COSTS Earth Station	Repeater	Office Central	Total
Radio Equipment	52	104	52	208
Fault Alarm System	9	5.1	9	23.1
Antenna and Waveguide	10	16	10	36
Civil Works	22	60	22	104
Tower and Building	17	36	17	70
Power	11	13	11	38
Land and Acquisition	3	24	3	30
Field Survey and FCC Coordination	7	7	7	21
Test Equipment and Spares	35	15.6	35	85.6
Miscellaneous (Documentation, Training, etc.)	19	10	19	48
Installation	39	36.3	39	114.3
TOTAL	224	327	224	778

TABLE E-27
COSTS OF MULTIPLEX EQUIPMENT (INSTALLED)
(in thousands of dollars)

	Item	COST Earth Station	Central Office	Total
1.	Digital Multiplexer			
	Common Equipment (M13 MUX)	20	20	20
	DS2 Interface (9 DS2)	11	11	22
	DS1 Interface (38 DS1)	15	15	30
	D3 Banton (38 Bands)	323	--	323
	56 KBPS Channels (912 Channels)	1,094	--	1,094
	VF Channels (912 Channels)	110	--	110
2.	Analog Multiplexers			
	SG/MG Equipment (20 MG)	36.5	126	212.5
	GP Equipment (100 GP)	108	--	108
	Channel Equipment (1200 Channels)	620	--	620

TABLE E-28
90 MPBS FIBER OPTIC SYSTEM COSTS

1.	Basic Terminal	
	Optical Terminal	29,000
	Fault and Alarm	8,000
	Power	16,000
	Test Equipment	20,000
	Spares	8,000
	Miscellaneous	10,000
	Installation	24,000
	Subtotal	115,000
2.	Repeater Location	
	Optical Repeater	32,000
	Charger Batteries	1,500
	Enclosure	3,500
	Installation	13,000
	Subtotal	60,000
3.	Cable	
	50 KM ($3.8/m)	190,000
	Installation:	
	large city (15 KM)	150,000
	suburb (20 KM)	140,000
	rural (15 KM)	45,000
	Subtotal	530,000

TABLE E-29. ANNUAL COSTS PER CHANNEL

CHANNEL	DIGITAL RADIO	FIBER OPTIC	ANALOG RADIO
DS2	60,120	116,200	
DS1	14,400	27,600	
56 KBPS	1,560	2,100	10,116
VF	900	1,400	843
9.6 KBPS	2,660	2,770	
4.8 KBPS	1,400	1,450	
2.4 KBPS	840	870	

TABLE E-30
DIGITAL RADIO ENTRANCE/EXIT LINKS
COSTS PER YEAR
(in thousands of dollars)

	1990	2000
DS2	57.1	51.4
DS1	13.7	12.3
56 KBPS	1.5	1.4
VF	0.9	0.8
9.6 KBPS	2.5	2.3
4.8 KBPS	1.3	1.2
2.4 KBPS	0.8	0.7

TABLE E-31
FIBER OPTIC ENTRANCE/EXIT LINK COST PER YEAR
(in thousands of dollars)

	1990	2000
DS2	81.34	73.2
DS1	19.34	17.39
56 KBPS	1.47	1.32
VF	.98	.88
9.6 KBPS	1.94	1.75
4.8 KBPS	1.00	.90
2.4 KBPS	.61	.55

TABLE E-32.
ANNUAL REVENUE REQUIREMENTS
WITHOUT TERRESTRIAL TAIL COSTS
(in thousands of dollars)

1982 dollars

Band Approach	Total Annual Revenue Requirement	Total Full Duplex Capability	VF	2.4 KBPS	4.8 KBPS	9.6 KBPS	56 KBPS	1.544 MBPS	6.3 MBPS	300 BPS
C-Band TDMA	24.2M	300 MBPS	5.5	0.2	0.41	0.82	4.8	132	526	26×10^{-3}
Ku-Band TDMA	37.8M	300 MBPS	8.513	0.32	639	1277	7449	205,4K	821.5	41×10^{-3}
Ka-Band TDMA										
C-Band FDMA	22.2		4.1	4.1	4.1	4.1	49.0			
Ku-Band FDMA	36.9		5.4	5.4	5.4	5.4	65.6			

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TABLE E-33

ANNUAL REVENUE REQUIREMENT FOR TAIL CIRCUITS

1982

DOLLARS COST PER YEAR

	DIGITAL RADIO	FIBER OPTIC	ANALOG RADIO
DS2	60,120	116,200	
DS1	14,400	27,600	
56 KBPS	1,560	2,100	10,116
VF	900	1,400	843
9.6	2,660	2,770	
4.8	1,400	1,450	
2.4	840	870	

Table E-34

BREAK EVEN DISTANCES IN MILES FOR TRUNKING NETWORKS

Band Approach	2.4	4.8	9.6	56	T1	VF Schedule 1	VF Schedule 2	VF Schedule 3
C band TDMA	95	158	307	112	92	566	479	395
Ku band TDMA	380	410	469	204	158	778	691	600
Ka band TDMA	107	116	140.5	81	30	300	212	137
Today's Tariffs								
C band FDMA						442	355	274
Ku band FDMA						478	390	308

TABLE E-35. TRENDS IN TRANSPONDER CONFIGURATIONS

RX: Receiver, TX: Transmitter, D: Distributer, C: Combiner
TD: Time Domain, SD: Space Domain, DEM: Demodulator, MOD: Modulator

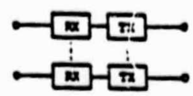
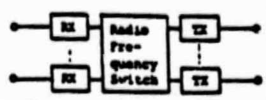
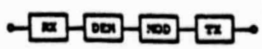
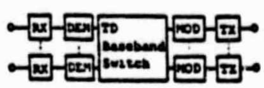
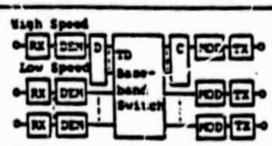
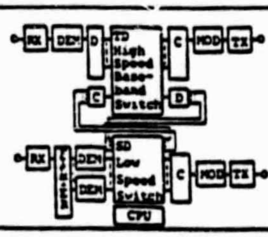
Case	Transponder configuration	Features & functions
I		Single beam/transponder. Connection between transponders is carried out at the earth station.
II		Multibeam. Connection between transponders is achieved by RF switch.
III		On board regeneration. Separation of the up and the down links.
IV		Multibeam. Time domain baseband switch.
V		Baseband signal is the same as low speed signal. Speed conversion. Time domain baseband channel switch.
VI		Connection between high speed signal and low speed signal. Speed conversion and on board regeneration. Proposed future transponder configuration.

TABLE E-36
PROJECTED TRUNKING EARTH STATION COSTS
(in thousands of dollars for the year 1982)
INCLUDING TRANSPONDER HOPPING

		1990			2000		
BAND	APPROACH	E/S COST	INSTALLATION AND INTEGRATION	TOTAL	E/S COST	INSTALLATION	TOTAL
C-Band	60 MBPS TDMA	715.5	286.1	1001.6	448.5	179.4	627.8
	1200 VF FDM/FDMA	662.2	264.9	927.1	455.5	182.2	637.7
Ku-Band	60 MBPS TDMA	601.0	240.4	841.4	392.0	158.8	548.8
	1500 VF FDM/FDMA	602.1	240.9	843.0	413.8	165.5	579.3
Ka-Band	512 MBPS TDMA	3650.0	1255.0	490.5	2996.0	806.98	3803.0
Ka-Band	512 MBPS TDMA	2290.0	546.0	2836.0	1308.0	523.2	1831.2

TABLE E-37

PROJECTED ANNUAL RECURRING COSTS

FOR TRUNKING NETWORKS

BAND AND APPROACH	FDX CAPACITY	ANNUAL REVENUE REQUIREMENTS		
		1982	1990	2000
C-BAND TDMA	300 MBS	$24,200,000	$15,700,000	$14,200,000
Ku-BAND TDMA	300 MBS	$39,100,000	$19,750,000	$10,000,000
Ka-BAND	2000 MBS		$132,960,000	$125,037,000
Ka-BAND USING LANIER TERMINAL COSTS	2000 MBS		$120,700,000	$113,287,070

TABLE-38

BREAKEVEN DISTANCE IN MILES FOR TRUNKING NETWORKS

YEAR	BAND AND APPROACH	2.4	4.8	9.6	56	T1	VF SCHEDULE 1	VF SCHEDULE 2	VF SCHEDULE 3
	C-BAND	95	158	307	112	92	566	479	395
1982	Ku-BAND	380	410	469	204	158	778	691	600
	Ka-BAND	---	---	---	---	---	---	---	---
	C-BAND	94	142	291	98	62	449	335	235
1990	Ku-BAND	117	134	170	104	74	483	371	270
	Ka-BAND	112	124	155	102	75	480	366	265
	Ka-BAND	110	121	149	98	64	436	322	222
	C-BAND	94	131	277	90	61	489	367	259
2000	Ku-BAND	71	76	87	74	21	239	117	70
	Ka-BAND	72	83	104	96	76	462	340	233
	Ka-BAND	71	81	100	91	65	417	295	189

APPENDIX F
NET ADDRESSABLE FORECASTS

F.1 INTRODUCTION

The development of the net addressable forecasts involved determining that portion of the net long haul forecasts that could be served by satellites, considering pertinent technical, institutional and cost factors (see Figure F-1).

F.2 METHODOLOGY

This analysis required input from our product line managers and tariff experts. Also important was a user survey conducted as part of a parallel effort involving the forecast of satellite provided customer premise services. The following major steps were conducted in the development of the net addressable forecasts:

a. Remove traffic not suitable for satellite transmission
b. Develop parametric cost model
c. Develop addressable forecasts for each band
d. Consider the effect of common carrier (plant-in-place) - determine net addressable forecasts.

F.3 REMOVE TRAFFIC NOT SUITABLE

Unacceptable user and application characteristics refer to usage and technical considerations which play a part in determining the suitability of a particular application for implementation on a satellite transmission system. Among the qualification criteria evaluated in determining satellite implementation suitability were the following:

a. Satellite delay. What is the ability of an application to tolerate a 600 millisecond delay caused by transmission via satellite? In data applications, this represents the delay between sending a block of information and the acknowledgement of its correct reception.

b. Accommodation of satellite delay. What effect will the cost and required technology necessary to overcome some satellite delay problems have on demand? Included are the costs of software conversion or special equipment, the projection of their availability and ease of implementation.

c. Multipoint signal distribution. What are the requirements of each application for broadcast-type signal distribution? The C-band CONUS coverage easily accommodates multipoint requirements such as are associated with the Network Video application, while Ku-band implementation of multipoint distribution requires a separate half channel for each additional drop. (The Ku-band system model is a point-to-point system, not adaptable to broadcast services. However, some anticipated Ku-band systems will be capable of broadcast distribution.)

d. Urgency of message delivery. How tolerant will users be to service interruptions and outages in excess of that experienced on terrestrial transmission media such as the public switched network? Movement to higher transmission frequencies is accompanied by the potential for lower levels of service availability. The impact of reduced availability varies with each application.

e. Miscellaneous characteristics. Several minor service considerations were also evaluated. They included: joint use of existing facilities, which may cause facility requirements to reflect the principal usage rather than the subordinate usage; and, insufficient traffic volume of a specific application to justify special communications facilities.

Quantification of these qualifying criteria included several conditions. Some were fundamental to the separation of satellite and terrestrial traffic (satellite delay), some were necessary to separate different forms of satellite transmission (multipoint signal distribution), and some were time oriented (accommodation of satellite delay). Each of the 31 service applications were evaluated for each characteristic in current terms (1980) and for the year 2000, based on trends established by judgment and analysis. Intermediate years also were evaluated if

a signficant change in trend was anticipated. A factor was established for each criterion for 1980 and 2000 which defined the proportion of market demand associated with a particular service application that could tolerate the requirements of the criterion. The individual factors derived for each criterion were consolidated into a composite qualifying factor and applied to the net long haul market demand for each application and each year of the 1980-2000 time span by computer modelling techniques. This completed the first step and the results are presented in Table F-1.

F.4 PARAMETRIC COST MODEL

The parametric cost model considered a broad number of system alternatives. This included terrestrial medium such as microwave and fiber optics as well as transmission at various satellite frequencies (6/4, 14/12, 30/20 GHz). Cost for these media were projected forward from 1980 to 1990 and 2000 (see Cost Analysis, Appendix E and Table F-2).

Three reasons are postulated for estimating alternate transmission service costs:

a. Service cost is a key factor in determining user service selection. The evaluation of satellite service costs can assist in the segregation of traffic demand between satellite and terrestrial means.

b. The economic advantages of satellite transmission are expected to improve over time, due essentially to more efficient satellite systems. The cost model examines projected changes in the service costs over the 1980-2000 period to determine whether the economic analyses will favor satellite systems.

c. Comparisons of alternative satellite systems (TDMA, FDM) and three frequencies (6/4, 14/12, 30/20 GHz) will indicate the optimum system configuration for delivery of individual services. The economics of providing end-to-end satellite service can thus be compared under a variety of system configurations.

Two other components go into the parametric cost model. The market distribution model must be used to route the traffic throughout the United States, and the traffic must be segmented into its various operating speeds. For voice services, the present tariffs are structured according to the division of cities. The cities are segmented into type A and type B cities. Schedule 1 (SC1) tariffs are used for traffic between listed (type A) cities. Schedule (SC2) tariffs are used for traffic between listed cities (type A) and unlisted cities (type B) while schedule 3 (SC3) tariffs are used for traffic between unlisted (type B) cities.

F.4.1 Removal of Traffic Corresponding to Distances Less Than Crossover Distances

Appendix E presented the cost analysis of trunking networks for C, Ku and Ka band using full transponder TDM/TDMA approach and FDM/FDMA approach. The same appendix also presented the crossover distances for various data speeds and voice. The crossover distances were based upon the comparison of end-to-end user services satellite costs with existing Bell Systems tariffs (See Table F-3).

The next step in determining the net addressable forecast was to eliminate the traffic transmitted within a distance less than crossover. This is equivalent to removing all the traffic that can be economically implemented by terrestrial facilities.

The cost analysis, presented in Appendix E, tabulated the crossover distance for voice and data. For data the standard data rates (available from Telco's) were used. The data services 2.4, 4.8, 9.7, 19.2, 56 and 1544 KBPS were considered.

For voice, three crossover distances were computed corresponding to schedule 1, schedule 2 and schedule 3 of FCC No 260 Type 2001 tariff. A composite crossover distance for voice was calculated by appropriately weighing the crossover distances corresponding to schedule 1, 2 and 3. The weights used in determining composite crossover distance to schedule 1, 2 and 3 are 65, 30 and 50% respectively.

It was seen in Appendix E that the crossover distances for digital services are lower with the full transponder TDM/TDMA approach, whereas for voice FDM/FDMA approach yields lower crossover distances. Also, most of the future systems are planned to be digital for all the bands whether C, Ku and Ka band. Considering these facts, the crossover distances for C, Ku or Ka band were computed for years 1990 and 2000 using TDM/TDMA approach. The crossover distances used in determining the net addressable market correspond to TDMA approach.

F.4.2 Distribute Demand to all SMSAs

In order to distribute the demand for traffic among the 313 SMSAs it was necessary to use the market distribution model. This was done for each of the 31 services. The same weighting and files given in Appendix C were used.

F.4.3 Determine Operating Speeds

The next step is to segment the thirty one services into the various operating speeds. This analysis done by engineers reviewed such things as the trend toward more high speed data. Services involving a great deal of CPU to CPU traffic which would normally go over high volume circuits were shown as such, for instance, data transfer. Slower services, such as data entry, were segmented into the slower speeds. The operating speeds of each service for 1980, 1990 and 2000 are indicated in Tables F-4, F-5 and F-6.

F.5 ADDRESSABLE FORECASTS

Using the percentages of traffic not suitable for satellite transmission and the parametric cost model described above, the addressable forecasts were developed for each band. These forecasts are in Tables F-7, F-9 and F-11; voice traffic is in thousands of half voice circuits, data traffic is in megabits per second, and video traffic is in equivalent 36 MHz Transponders. The percent changes from the net long haul forecasts appear in Tables F-8, F-10 and F-12.

F.6 NET ADDRESSABLE FORECASTS (REMOVE TRAFFIC LOST BECAUSE OF PLANT IN PLACE)

There exists across the United States a tremendous investment in existing plant in place. Such things as AT&T's and Western Union's extensive microwave systems were largely installed several years ago. Once this plant is installed it becomes a sunk cost. The marginal cost is the cost of maintaining the system. This is the true cost with which satellite systems must compete. As competition increases companies will compete not so much on a tariff basis but on a service basis, for example, a voice grade line New York to Los Angeles. Terrestrial systems will tend to underbid their true cost of offering the service in order to cover the cost of maintaining their present system and covering some of the sunk cost.

As the marginal cost of maintaining the plant in place increases, as the equipment becomes older, and the cost of providing services by satellite becomes cheaper a higher percentage of the market will be captured by satellites. This is reflected in the percent of traffic removed because of plant-in-place (Table F-13). These percentages were obtained by consulting tariff experts and engineers. The major impact was expected to be on voice since the current plant in place was established to mainly handle this type of traffic. The percent of data to remove was estimated by using the percent of data which uses voice facilities times the percent of voice traffic to remove because of plant in place (see Appendix D).

At this point in the forecasting process, a maximum addressable was developed by selecting the highest forecast across the three bands for each service for each year (see Table F-14); in all cases either C or Ku band forecasts were the highest so the maximum consisted of only C and Ku traffic. Then the high, expected and low estimates of the amount of traffic that should be removed due to common carrier were used to calculate the high, expected and low net addressable forecasts, considering common carrier (see Tables F-15, F-17, and F-19); the percentage changes from the maximum forecasts to the forecasts considering common carrier appear in Tables F-16, F-18 and F-20. In preparation for Task 2.0 the expected net addressable traffic considering common carrier also were calculated separately for each band. These forecasts appear in Table F-21, F-22 and F-23.

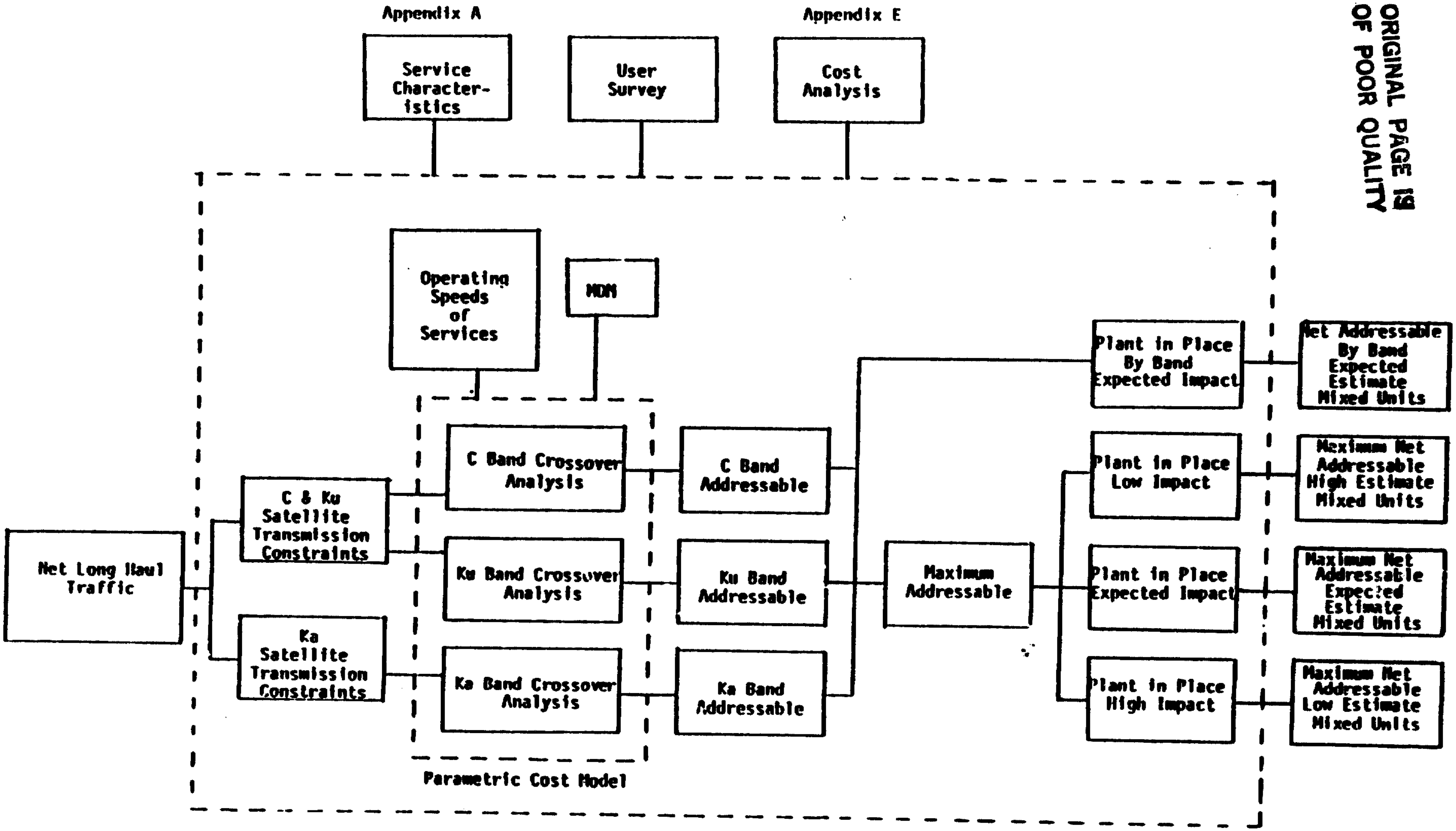


FIGURE F-1. ACTIVITY FLOW FOR NET ADDRESSABLE FORECASTS

TABLE F-1. PERCENT OF TRAFFIC NOT SUITABLE FOR SATELLITE TRANSMISSION

	BAND		
SERVICES	C	Ku	Ka
MTS (Residential)			
MTS (Business)			
Private Line			
Mobile			
Public Radio			
Commercial and Religious			30A
Occasional			30A
CATV Music			30A
Recording			
Data Transfer			
Batch Processing			
Data Entry			
Remote Job Entry			
Inquiry/Response	60B	60B	60B
Timesharing	60B	60B	60B
USPS/EMSS			
Mailbox			
Administrative Messages			
Facsimile			
Communicating Word Processors			
TWX/Telex			
Mailgram/Telegram/Money Order			
Point of Sale			
Videotext/Teletext			
Telemonitoring Service			
Secure Voice			
Network			30A
CATV			30A
Occasional			30A
Recording Channel			30A
Teleconferencing			15A

A = Availability B = Connectivity (i.e., time delay tolerance)

TABLE F-2. MAJOR COSTING ACTIVITIES

- Define the trunking earth stations.
- Size the earth stations for C, Ku and Ka Band.
- Vendor Survey to obtain the earth station component costs.
- Cost of the earth station
- Cost of the space segment
- Cost of the terrestrial tails. Digital microwave, fiber optics, etc.
- End to end user costs for various trunking services
- Terrestrial tariffs for various services
- Crossover for terrestrial tariffs for various trunking services with satellite trunking systems.

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TABLE F-3. BREAKEVEN DISTANCE IN MILES FOR TRUNKING NETWORKS

		OPERATING SPEEDS							
YEAR	BAND AND APPROACH	2.4	4.8	9.6	56	T1	SCHEDULE 1	VF SCHEDULE 2	SCHEDULE 3
	C-BAND	95	158	307	112	92	566	479	395
1982	Ku-BAND	380	410	469	304	158	778	691	600
	Ka-BAND	---	---	---	---	---	---	---	---
	C-BAND	94	142	291	98	62	449	335	235
1990	Ku-BAND	117	134	170	104	74	485	371	270
	Ka-BAND	112	124	155	102	75	480	366	265
	Ka-BAND	110	121	149	98	64	436	322	222
	C-BAND	94	131	277	90	61	489	367	259
2000	Ku-BAND	71	76	87	74	21	239	117	70
	Ka-BAND	72	83	104	96	76	462	340	233
	Ka-BAND	71	81	100	91	65	417	295	189

TABLE F-4. PERCENT OF TRAFFIC FOR SERVICES BY OPERATING SPEEDS (1980)

SERVICES	OPERATING SPEEDS 2.4	4.8	9.6	56	T-1	SC1	SC2	SC3
MTS (residential)						65	30	5
MTS (business)						65	30	5
Private Line						65	30	5
Mobile						65	30	5
Public Radio								
Commercial and Religious								
Occasional								
CATV Music								
Recording								
Data Transfer			25	70	5			
Batch Processing	70	20	10					
Data Entry	70	20	10					
Remote Job Entry	70	20	10					
Inquiry/Response	70	20	10					
Timesharing	50	20	20	10				
USPS/EMSS	20	10	60	10				
Mailbox	70	20	10					
Administrative Messages	70	20	10					
Facsimile	70	20	10					
Communicating Word Processors	70	20	10					
TWX/Telex	70	20	10					
Mailgram/Telegram/Money Order	70	20	10					
Point of Sale	70	20	10					
Telemonitoring Service	70	20	10					
Secure Voice	20	60	20					
Network								
CATV								
Occasional								
Recording Channel								
Teleconferencing								

TABLE F-5. PERCENT OF TRAFFIC FOR SERVICES BY OPERATING SPEEDS (1990)

SERVICES	OPERATING SPEEDS							
	2.4	4.8	9.6	56	T-1	SC1	SC2	SC3
MTS (residential)						65	30	5
MTS (business)						65	30	5
Private Line						65	30	5
Mobile						65	30	5
Public Radio								
Commercial and Religious								
Occasional								
CATV Music								
Recording								
Data Transfer			20	50	30			
Batch Processing	20	30	40	10				
Data Entry	20	70	10					
Remote Job Entry	20	70	10					
Inquiry/Response	20	70	10					
Timesharing	20	20	40	20				
USPS/EMSS		10	60	30				
Mailbox	20	70	10					
Administrative Messages	20	70	10					
Facsimile	20	70	10					
Communicating Word Processors	20	70	10					
TWX/Telex	20	70	10					
Mailgram/Telegram/Money Order	20	70	10					
Point of Sale	20	70	10					
Telemonitoring Service	20	70	10					
Secure Voice	20	30	50					
Network								
CATV								
Occasional								
Recording Channel								
Teleconferencing								

TABLE F-6. PERCENT OF TRAFFIC FOR SERVICES BY OPERATING SPEEDS (2000)

SERVICES	OPERATING SPEEDS 2.4	4.8	9.6	56	T1	SC1	SC2	SC3
MTS (residential)						65	30	5
MTS (business)						65	30	5
Private Line						65	30	5
Mobile						65	30	5
Public Radio								
Commercial and Religious								
Occasional								
CATV Music								
Recording								
Data Transfer			10	20	70			
Batch Processing		30	40	30				
Data Entry	10	20	70					
Remote Job Entry		10	20	70				
Inquiry/Response	10	20	70					
Timesharing		10	20	70				
USPS/EMSS		10	20	70				
Mailbox	10	20	70					
Administrative Messages	10	20	70					
Facsimile	10	20	70					
Communicating Word Processors	10	20	70					
TWX/Telex	10	20	70					
Mailgram/Telegram/Money Order	10	20	70					
Point of Sale	10	20	70					
Telemonitoring Service	10	20	70					
Secure Voice	10	20	70					
Network								
CATV								
Occasional								
Recording Channel								
Teleconferencing								

TABLE F-7. ADDRESSABLE C-BAND FORECASTS

SERVICE	YEAR 1980	1990	2000
VOICE (1000's HVC's)			
MTS (Residential)	211.3	568.5	1186.3
MTS (Business)	538.1	1802.3	3977.6
Private Line	209.8	1098.0	2900.0
Mobile	0.5	16.0	48.8
Public Radio	0.3	1.8	2.6
Commercial and Religious	0.5	2.0	3.2
Occasional	0.9	1.8	2.7
CATV Music	0.1	0.3	1.2
Recording		0.0	0.4
TOTAL	961.5	3490.6	8122.9
DATA (Mbps)			
Data Transfer	26.7	63.6	238.2
Batch Processing	49.8	100.4	134.3
Data Entry	7033.9	9716.8	8903.0
Remote Job Entry	176.8	1100.7	1511.1
Inquiry/Response	78.9	508.2	791.6
Timesharing	61.0	128.9	182.3
USPS/EMSS		81.5	143.4
Mailbox	5.4	65.0	76.6
Administrative Messages	1731.4	5382.5	7777.4
Facsimile	359.5	609.8	413.1
Communicating Word Processors	11.0	41.1	72.4
TWX/TELEX	34.9	22.2	13.6
Mailgram/Telegram/Money Orders	0.2	0.2	0.3
Point of Sale	61.0	615.8	503.9
Videotext/Teletext	0.1	272.7	633.5
Telemonitoring Service	0.1	0.5	2.1
Secure Voice	0.8	25.1	140.8
TOTAL	9631.6	18735.1	21537.5
VIDEO (Transponders)			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel		0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE F-8. ADDRESSABLE C-BAND: PERCENT OF NLH NOT ADDRESSABLE

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (Residential)	52.8	42.9	45.7
MTS (Business)	53.4	44.0	46.7
Private Line	53.7	44.3	47.0
Mobile	53.3	44.0	46.6
Public Radio	0.0	0.0	0.0
Commercial and Religious	0.0	0.0	0.0
Occasional	0.0	0.0	0.0
CATV Music	0.0	0.0	0.0
Recording	0.0	0.0	0.0
TOTAL	53.3	43.9	46.6
DATA			
Data Transfer	21.9	17.4	15.1
Batch Processing	18.4	25.0	23.8
Data Entry	18.4	20.9	29.7
Remote Job Entry	18.4	20.9	18.5
Inquiry/Response	18.4	20.8	29.7
Timesharing	20.9	24.4	18.5
USPS/EMSS	29.5	28.2	29.7
Mailbox	17.8	20.3	29.0
Administrative Messages	17.8	20.3	29.0
Facsimile	17.8	20.3	29.0
Communicating Word Processors	17.8	20.3	29.0
TWX/TELEX	17.9	20.4	29.1
Mailgram/Telegram/Money Orders	22.6	25.4	34.1
Point of Sale	18.2	20.8	29.6
Videotext/Teletext	18.3	20.8	29.4
Telemonitoring Service	18.2	20.8	29.6
Secure Voice	20.0	23.0	25.4
TOTAL	18.3	20.8	28.4
VIDEO			
Network	0.0	0.0	0.0
CATV	0.0	0.0	0.0
Occasional	0.0	0.0	0.0
Recording Channel	0.0	0.0	0.0
Teleconferencing	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0

TABLE F-9. ADDRESSABLE KU-BAND FORECASTS

SERVICE	YEAR		
	1980	1990	2000
VOICE (1000's HVC's)			
MTS (Residential)	150.2	540.4	1673.2
MTS (Business)	385.4	1715.8	5596.3
Private Line	149.9	1045.2	4086.8
Mobile	0.4	15.2	68.4
Public Radio	0.3	1.8	2.6
Commercial and Religious	0.5	2.0	3.2
Occasional	0.9	1.8	2.7
CATV Music	0.1	0.3	1.2
Recording		0.0	0.4
TOTAL	687.7	3322.4	11434.9
DATA (Mbps)			
Data Transfer	22.9	64.7	259.8
Batch Processing	34.0	106.4	155.0
Data Entry	4795.2	9880.1	11055.5
Remote Job Entry	120.6	1119.2	1639.5
Inquiry/Response	21.5	206.7	393.2
Timesharing	17.4	54.5	79.1
USPS/EMSS		89.5	178.1
Mailbox	3.7	66.1	94.7
Administrative Messages	1184.8	5471.6	9620.4
Facsimile	246.0	619.9	510.9
Communicating Word Processors	7.6	41.7	89.6
TWX/TELEX	23.8	22.6	16.8
Mailgram/Telegram/Money Orders	0.1	0.2	0.3
Point of Sale	41.5	626.2	627.8
Videotext/Teletext	0.1	277.1	784.2
Telemonitoring Service	0.1	0.6	2.7
Secure Voice	0.6	26.9	170.2
TOTAL	6519.7	18673.9	25678.0
VIDEO (Transponders)			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel		0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE F-10. ADDRESSABLE KU-BAND: PERCENT OF NLH NOT ADDRESSABLE

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (Residential)	66.4	45.7	23.5
MTS (Business)	66.6	46.7	25.0
Private Line	66.9	47.0	25.3
Mobile	66.5	46.6	25.2
Public Radio	0.0	0.0	0.0
Commercial and Religious	0.0	0.0	0.0
Occasional	0.0	0.0	0.0
CATV Music	0.0	0.0	0.0
Recording	0.0	0.0	0.0
TOTAL	66.6	46.6	24.9
DATA			
Data Transfer	33.2	16.0	7.4
Batch Processing	44.4	20.5	12.1
Data Entry	44.4	19.6	12.7
Remote Job Entry	44.4	19.6	11.6
Inquiry/Response	44.4	19.6	12.7
Timesharing	43.5	20.1	11.6
USPS/EMSS	45.9	21.1	12.8
Mailbox	43.8	19.0	12.2
Administrative Messages	43.8	19.0	12.2
Facsimile	43.8	19.0	12.2
Communicating Word Processors	43.8	19.0	12.2
TWX/TELEX	43.9	19.1	12.2
Mailgram/Telegram/Money Orders	43.2	24.1	16.6
Point of Sale	44.3	19.4	12.3
Videotext/Teletext	43.9	19.5	12.6
Telemonitoring Service	44.4	19.5	12.5
Secure Voice	41.8	17.4	9.8
TOTAL	44.2	19.4	12.3
VIDEO			
Network	0.0	0.0	0.0
CATV	0.0	0.0	0.0
Occasional	0.0	0.0	0.0
Recording Channel	0.0	0.0	0.0
Teleconferencing	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0

TABLE F-11. ADDRESSABLE KA-BAND FORECASTS

SERVICE	YEAR 1980	1990	2000
VOICE (1000's HVC's)			
MTS (Residential)		544.0	1233.4
MTS (Business)		1727.2	4130.7
Private Line		1052.1	3011.8
Mobile		15.3	50.7
Public Radio		1.2	1.8
Commercial and Religious		1.4	2.2
Occasional		1.3	1.9
CATV Music		0.3	1.2
Recording		0.0	0.4
TOTAL		3342.8	8434.2
DATA (Mbps)			
Data Transfer		65.1	243.7
Batch Processing		108.1	150.8
Data Entry		10024.1	10800.2
Remote Job Entry		1135.6	1584.2
Inquiry/Response		83.9	153.6
Timesharing		22.1	30.6
USPS/EMSS		91.1	173.9
Mailbox		67.0	92.6
Administrative Messages		5549.7	9402.5
Facsimile		628.7	499.4
Communicating Word Processors		42.3	87.5
TWX/TELEX		22.9	16.4
Mailgram/Telegram/Money Orders		0.2	0.3
Point of Sale		635.9	613.2
Videotext/Teletext		281.1	766.2
Telemonitoring Service		0.6	2.6
Secure Voice		27.4	167.0
TOTAL		18785.6	24784.8
VIDEO (Transponders)			
Network		30.0	29.4
CATV		57.7	47.7
Occasional		29.1	25.2
Recording Channel		0.0	0.9
Teleconferencing		132.6	208.5
TOTAL		249.4	311.7

TABLE F-12. ADDRESSABLE KA-BAND: PERCENT OF NLH NOT ADDRESSABLE

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (Residential)		45.4	43.6
MTS (Business)		46.3	44.6
Private Line		46.7	45.0
Mobile		46.3	44.6
Public Radio		0.0	0.0
Commercial and Religious		0.0	0.0
Occasional		0.0	0.0
CATV Music		0.0	0.0
Recording		0.0	0.0
TOTAL		46.2	44.6
DATA			
Data Transfer		15.5	13.2
Batch Processing		19.2	14.5
Data Entry		18.4	14.7
Remote Job Entry		18.4	14.6
Inquiry/Response		18.4	14.7
Timesharing		18.9	14.6
USPS/EMSS		19.8	14.8
Mailbox		17.8	14.2
Administrative Messages		17.8	14.2
Facsimile		17.8	14.2
Communicating Word Processors		17.8	14.2
TWX/TELEX		17.9	14.2
Mailgram/Telegram/Money Orders		22.9	18.9
Point of Sale		18.2	14.4
Videotext/Teletext		18.3	14.6
Telemonitoring Service		18.3	14.5
Secure Voice		16.2	11.5
TOTAL		18.2	14.4
VIDEO			
Network		0.0	0.0
CATV		0.0	0.0
Occasional		0.0	0.0
Recording Channel		0.0	0.0
Teleconferencing		0.0	0.0
TOTAL		0.0	0.0

TABLE F-13. ESTIMATES (PERCENTAGES) OF TRAFFIC TO BE REMOVED DUE TO COMMON CARRIER

SERVICE		YEAR 1980	1990	2000
Voice (MTS) -	High	98	67.0	33.0
	Expected	98	73.5	50.0
	Low	98	80.0	67.0
Data (All) -	High	93	45.0	11.0
	Expected	93	49.5	16.5
	Low	93	54.0	22.0

TABLE F-14. MAXIMUM ADDRESSABLE FORECASTS

SERVICE	YEAR 1980	1990	2000
VOICE (1000's HVC's)			
MTS (Residential)	211.3	568.5	1673.2
MTS (Business)	538.1	1802.3	5596.3
Private Line	209.8	1098.0	4086.8
Mobile	0.5	16.0	68.4
Public Radio	0.3	1.8	2.6
Commercial and Religious	0.5	2.0	3.2
Occasional	0.9	1.8	2.7
CATV Music	0.1	0.3	1.2
Recording		0.0	0.4
TOTAL	961.5	3490.6	11434.9
DATA (Mbps)			
Data Transfer	26.7	65.1	259.8
Batch Processing	49.8	108.1	155.0
Data Entry	7033.9	10024.1	11055.5
Remote Job Entry	176.8	1135.6	1639.5
Inquiry/Response	78.9	508.2	791.6
Timesharing	61.0	128.9	182.3
USPS/EMSS		91.1	178.1
Mailbox	5.4	67.0	94.7
Administrative Messages	1731.4	5549.7	9620.4
Facsimile	359.5	628.7	510.9
Communicating Word Processors	11.0	42.3	89.6
TWX/TELEX	34.9	22.9	16.8
Mailgram/Telegram/Money Orders	0.2	0.2	0.3
Point of Sale	61.0	635.9	627.8
Videotext/Teletext	0.1	281.1	784.2
Telemonitoring Service	0.1	0.6	2.7
Secure Voice	0.8	27.4	170.2
TOTAL	9631.6	19316.7	26179.5
VIDEO (Transponders)			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel		0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE F-15. MAXIMUM NET ADDRESSABLE, HIGH ESTIMATE

SERVICE	YEAR 1980	YEAR 1990	YEAR 2000
VOICE (1000's HVC's)			
MTS (Residential)	4.2	187.6	1121.1
MTS (Business)	10.8	594.8	3749.5
Private Line	209.8	1098.0	4086.8
Mobile	0.5	16.0	68.4
Public Radio	0.3	1.8	2.6
Commercial and Religious	0.5	2.0	3.2
Occasional	0.9	1.8	2.7
CATV Music	0.1	0.3	1.2
Recording		0.0	0.4
TOTAL	227.1	1902.2	9036.0
DATA (Mbps)			
Data Transfer	1.9	35.8	231.3
Batch Processing	3.5	59.4	137.9
Data Entry	492.4	5513.2	9839.4
Remote Job Entry	12.4	624.6	1459.1
Inquiry/Response	5.5	279.5	704.5
Timesharing	4.3	70.9	162.2
USPS/EMSS		50.1	158.5
Mailbox	0.4	36.9	84.3
Administrative Messages	121.2	3052.3	8562.2
Facsimile	25.2	345.8	454.7
Communicating Word Processors	0.8	23.3	79.7
TWX/TELEX	2.4	12.6	15.0
Mailgram/Telegram/Money Orders	0.0	0.1	0.3
Point of Sale	4.3	349.7	558.8
Videotext/Teletext	0.0	154.6	698.0
Telemonitoring Service	0.0	0.3	2.4
Secure Voice	0.1	15.0	151.5
TOTAL	674.2	10624.2	23299.8
VIDEO (Transponders)			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel		0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE F-16. MAXIMUM NET ADDRESSABLE, HIGH ESTIMATE: PERCENT OF MAXIMUM ADDRESSABLE NOT INCLUDED

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (Residential)	98.0	67.0	33.0
MTS (Business)	98.0	67.0	33.0
Private Line	0.0	0.0	0.0
Mobile	0.0	0.0	0.0
Public Radio	0.0	0.0	0.0
Commercial and Religious	0.0	0.0	0.0
Occasional	0.0	0.0	0.0
CATV Music	0.0	0.0	0.0
Recording	0.0	0.0	0.0
TOTAL	76.3	45.5	21.0
DATA			
Data Transfer	93.0	45.0	11.0
Batch Processing	93.0	45.0	11.0
Data Entry	93.0	45.0	11.0
Remote Job Entry	93.0	45.0	11.0
Inquiry/Response	93.0	45.0	11.0
Timesharing	93.0	45.0	11.0
USPS/EMSS		45.0	11.0
Mailbox	93.0	45.0	11.0
Administrative Messages	93.0	45.0	11.0
Facsimile	93.0	45.0	11.0
Communicating Word Processors	93.0	45.0	11.0
TWX/TELEX	93.0	45.0	11.0
Mailgram/Telegram/Money Orders	93.0	45.0	11.0
Point of Sale	93.0	45.0	11.0
Videotext/Teletext	93.0	45.0	11.0
Telemonitoring Service	93.0	45.0	11.0
Secure Voice	93.0	45.0	11.0
TOTAL	93.0	45.0	11.0
VIDEO			
Network	0.0	0.0	0.0
CATV	0.0	0.0	0.0
Occasional	0.0	0.0	0.0
Recording Channel	0.0	0.0	0.0
Teleconferencing	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0

TABLE F-17. MAXIMUM NET ADDRESSABLE, EXPECTED ESTIMATE

SERVICE	YEAR 1980	1990	2000
VOICE (1000's HVC's)			
MTS (Residential)	4.2	145.0	836.6
MTS (Business)	10.8	459.6	2798.2
Private Line	209.8	1098.0	4086.8
Mobile	0.5	16.0	68.4
Public Radio	0.3	1.8	2.6
Commercial and Religious	0.5	2.0	3.2
Occasional	0.9	1.8	2.7
CATV Music	0.1	0.3	1.2
Recording		0.0	0.4
TOTAL	227.1	1724.4	7800.2
DATA (Mbps)			
Data Transfer	1.9	32.9	217.0
Batch Processing	3.5	54.6	129.4
Data Entry	492.4	5062.2	9231.4
Remote Job Entry	12.4	573.5	1369.0
Inquiry/Response	5.5	256.7	661.0
Timesharing	4.3	65.1	152.2
USPS/EMSS		46.0	148.7
Mailbox	0.4	33.8	79.1
Administrative Messages	121.2	2802.6	8033.1
Facsimile	25.2	317.5	426.6
Communicating Word Processors	0.8	21.4	74.8
TWX/TELEX	2.4	11.6	14.0
Mailgram/Telegram/Money Orders	0.0	0.1	0.3
Point of Sale	4.3	321.1	524.2
Videotext/Teletext	0.0	141.9	654.8
Telemonitoring Service	0.0	0.3	2.2
Secure Voice	0.1	13.8	142.1
TOTAL	674.2	9755.0	21859.9
VIDEO (Transponders)			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel		0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE F-18. MAXIMUM NET ADDRESSABLE, EXPECTED ESTIMATE: PERCENT OF MAXIMUM ADDRESSABLE NOT INCLUDED

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (Residential)	98.0	74.5	50.0
MTS (Business)	98.0	74.5	50.0
Private Line	0.0	0.0	0.0
Mobile	0.0	0.0	0.0
Public Radio	0.0	0.0	0.0
Commercial and Religious	0.0	0.0	0.0
Occasional	0.0	0.0	0.0
CATV Music	0.0	0.0	0.0
Recording	0.0	0.0	0.0
TOTAL	76.3	50.6	31.8
DATA			
Data Transfer	93.0	49.5	16.5
Batch Processing	93.0	49.5	16.5
Data Entry	93.0	49.5	16.5
Remote Job Entry	93.0	49.5	16.5
Inquiry/Response	93.0	49.5	16.5
Timesharing	93.0	49.5	16.5
USPS/EMSS		49.5	16.5
Mailbox	93.0	49.5	16.5
Administrative Messages	93.0	49.5	16.5
Facsimile	93.0	49.5	16.5
Communicating Word Processors	93.0	49.5	16.5
TWX/TELEX	93.0	49.5	16.5
Mailgram/Telegram/Money Orders	93.0	49.5	16.5
Point of Sale	93.0	49.5	16.5
Videotext/Teletext	93.0	49.5	16.5
Telemonitoring Service	93.0	49.5	16.5
Secure Voice	93.0	49.5	16.5
TOTAL	93.0	49.5	16.5
VIDEO			
Network	0.0	0.0	0.0
CATV	0.0	0.0	0.0
Occasional	0.0	0.0	0.0
Recording Channel	0.0	0.0	0.0
Teleconferencing	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0

TABLE F-19. MAXIMUM NET ADDRESSABLE, LOW ESTIMATE

SERVICE	YEAR 1980	1990	2000
VOICE (1000's HVC's)			
MTS (Residential)	4.2	113.7	552.2
MTS (Business)	10.8	360.5	1846.8
Private Line	209.8	1098.0	4086.8
Mobile	0.5	16.0	68.4
Public Radio	0.3	1.8	2.6
Commercial and Religious	0.5	2.0	3.2
Occasional	0.9	1.8	2.7
CATV Music	0.1	0.3	1.2
Recording		0.0	0.4
TOTAL	227.1	1594.0	6564.3
DATA (Mbps)			
Data Transfer	1.9	29.9	202.7
Batch Processing	3.5	49.7	120.9
Data Entry	492.4	4611.1	8623.3
Remote Job Entry	12.4	522.4	1278.8
Inquiry/Response	5.5	233.8	617.4
Timesharing	4.3	59.3	142.2
USPS/EMSS		41.9	138.9
Mailbox	0.4	30.8	73.9
Administrative Messages	121.2	2552.8	7503.9
Facsimile	25.2	289.2	398.5
Communicating Word Processors	0.8	19.5	69.9
TWX/TELEX	2.4	10.5	13.1
Mailgram/Telegram/Money Orders	0.0	0.1	0.3
Point of Sale	4.3	292.5	489.7
Videotext/Teletext	0.0	129.3	611.[illegible]
Telemonitoring Service	0.0	0.3	2.1
Secure Voice	0.1	12.6	132.8
TOTAL	674.2	8885.7	20420.0
VIDEO (Transponders)			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel		0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE F-20. MAXIMUM NET ADDRESSABLE, LOW ESTIMATE: PERCENT OF MAXIMUM ADDRESSABLE NOT INCLUDED

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (Residential)	98.0	80.0	67.0
MTS (Business)	98.0	80.0	67.0
Private Line	0.0	0.0	0.0
Mobile	0.0	0.0	0.0
Public Radio	0.0	0.0	0.0
Commercial and Religious	0.0	0.0	0.0
Occasional	0.0	0.0	0.0
CATV Music	0.0	0.0	0.0
Recording	0.0	0.0	0.0
TOTAL	76.3	54.3	42.6
DATA			
Data Transfer	93.0	54.0	22.0
Batch Processing	93.0	54.0	22.0
Data Entry	93.0	54.0	22.0
Remote Job Entry	93.0	54.0	22.0
Inquiry/Response	93.0	54.0	22.0
Timesharing	93.0	54.0	22.0
USPS/EMSS		54.0	22.0
Mailbox	93.0	54.0	22.0
Administrative Messages	93.0	54.0	22.0
Facsimile	93.0	54.0	22.0
Communicating Word Processors	93.0	54.0	22.0
TWX/TELEX	93.0	54.0	22.0
Mailgram/Telegram/Money Orders	93.0	54.0	22.0
Point of Sale	93.0	54.0	22.0
Videotext/Teletext	93.0	54.0	22.0
Telemonitoring Service	93.0	54.0	22.0
Secure Voice	93.0	54.0	22.0
TOTAL	93.0	54.0	22.0
VIDEO			
Network	0.0	0.0	0.0
CATV	0.0	0.0	0.0
Occasional	0.0	0.0	0.0
Recording Channel	0.0	0.0	0.0
Teleconferencing	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0

TABLE F-21. C-BAND NET ADDRESSABLE, EXPECTED ESTIMATE

SERVICE	YEAR 1980	1990	2000
VOICE (1000's HVC's)			
MTS (Residential)	4.2	145.0	593.2
MTS (Business)	10.8	459.6	1988.8
Private Line	209.8	1098.0	2900.0
Mobile	0.5	16.0	48.8
Public Radio	0.3	1.8	2.6
Commercial and Religious	0.5	2.0	3.2
Occasional	0.9	1.8	2.7
CATV Music	0.1	0.3	1.2
Recording		0.0	0.4
TOTAL	227.1	1724.4	5540.9
DATA (Mbps)			
Data Transfer	1.9	32.1	198.9
Batch Processing	3.5	50.7	112.1
Data Entry	492.4	4907.0	7434.0
Remote Job Entry	12.4	555.9	1261.8
Inquiry/Response	5.5	256.7	661.0
Timesharing	4.3	65.1	152.2
USPS/EMSS		41.2	119.8
Mailbox	0.4	32.8	63.9
Administrative Messages	121.2	2718.2	6494.2
Facsimile	25.2	307.9	344.9
Communicating Word Processors	0.8	20.7	60.5
TWX/TELEX	2.4	11.2	11.3
Mailgram/Telegram/Money Orders	0.0	0.1	0.2
Point of Sale	4.3	311.0	420.8
Videotext/Teletext	0.0	137.7	529.0
Telemonitoring Service	0.0	0.3	1.8
Secure Voice	0.1	12.7	117.5
TOTAL	674.2	9461.2	17983.8
VIDEO (Transponders)			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel		0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE F-22. KU-BAND NET ADDRESSABLE EXPECTED ESTIMATE

SERVICE	YEAR 1980	1990	2000
VOICE (1000's HVC's)			
MTS (Residential)	3.0	137.8	836.6
MTS (Business)	7.7	437.5	2798.2
Private Line	149.9	1045.2	4086.8
Mobile	0.4	15.2	68.4
Public Radio	0.3	1.8	2.6
Commercial and Religious	0.5	2.0	3.2
Occasional	0.9	1.8	2.7
CATV Music	0.1	0.3	1.2
Recording		0.0	0.4
TOTAL	162.8	1641.6	7800.2
DATA (Mbps)			
Data Transfer	1.6	32.7	217.0
Batch Processing	2.4	53.7	129.4
Data Entry	335.7	4989.5	9231.4
Remote Job Entry	8.4	565.2	1369.0
Inquiry/Response	1.5	104.4	328.3
Timesharing	1.2	27.5	66.1
USPS/EMSS		45.2	148.7
Mailbox	0.3	33.4	79.1
Administrative Messages	82.9	2763.1	8033.1
Facsimile	17.2	313.0	426.6
Communicating Word Processors	0.5	21.1	74.8
TWX/TELEX	1.7	11.4	14.0
Mailgram/Telegram/Money Orders	0.0	0.1	0.3
Point of Sale	2.9	316.2	524.2
Videotext/Teletext	0.0	140.0	654.8
Telemonitoring Service	0.0	0.3	2.2
Secure Voice	0.1	13.6	142.1
TOTAL	456.4	9430.3	21441.1
VIDEO (Transponders)			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel		0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

C-4

TABLE F-23. KA-BAND NET ADDRESSABLE, EXPECTED ESTIMATE

SERVICE	YEAR 1980	1990	2000
VOICE (1000's HVC's)			
MTS (Residential)		138.7	616.7
MTS (Business)		440.4	2065.4
Private Line		1052.1	3011.8
Mobile		15.3	50.7
Public Radio		1.2	1.8
Commercial and Religious		1.4	2.2
Occasional		1.3	1.9
CATV Music		0.3	1.2
Recording		0.0	0.4
TOTAL		1650.8	5752.1
DATA (Mbps)			
Data Transfer		32.9	203.4
Batch Processing		54.6	125.9
Data Entry		5062.2	9018.1
Remote Job Entry		573.5	1322.8
Inquiry/Response		42.4	128.3
Timesharing		11.2	25.5
USPS/EMSS		46.0	145.2
Mailbox		33.8	77.3
Administrative Messages		2802.6	7851.1
Facsimile		317.5	417.0
Communicating Word Processors		21.4	73.1
TWX/TELEX		11.6	13.7
Mailgram/Telegram/Money Orders		0.1	0.3
Point of Sale		321.1	512.1
Videotext/Teletext		141.9	639.8
Telemonitoring Service		0.3	2.2
Secure Voice		13.8	139.4
TOTAL		9486.7	20695.3
VIDEO (Transponders)			
Network		30.0	29.4
CATV		57.7	47.7
Occasional		29.1	25.2
Recording Channel		0.0	0.9
Teleconferencing		132.6	208.5
TOTAL		249.4	311.7

APPENDIX G
CAPACITY REQUIREMENTS

G.1 INTRODUCTION

The purpose of this subtask is to convert the net addressable forecasts from peak hour half-voice circuits (voice), MBPS (Data), and transponders (video) to equivalent transponders so that a comparison can be made among required, potential and actual capacities. To accomplish this the following steps were performed:

a. Conducted a thorough analysis of techniques for improving spectrum utilization
b. Specification of high, expected and low estimates of technological changes
c. Presentation of high, expected and low estimates of capacity requirements.

G.2 IMPROVING SPECTRUM UTILIZATION

The results of a thorough analysis of techniques for improving spectrum utilization are presented in a detailed report (Annex 1) which appears at the end of this Appendix. This report covers three major topics: Modulation techniques, Frequency reuse and Reduced satellite spacing. The information in these topics was used to specify estimates of technological improvements.

G.3 ESTIMATES OF TECHNOLOGICAL CHANGES

In the development of capacity requirements, improvements in modulation techniques and coding techniques and the percent of voice on analog and the percent on digital were considered. The numbers of half voice circuits per 36 MHz transponder were based on expected improvements in frequency and amplitude modulation techniques. The numbers of KBPS per half voice circuit were considered a function of improvements in coding techniques. The numbers of MBPS per 36 MHz transponder were based on expected improvements in digital modulation techniques. The percentages of voice on analog and the

percentages on digital were forecast on the basis of trends indicating a growing increase in digital services. The estimates of these technological changes are presented in Table G-1. Estimates #1, #2 and #3 correspond to improvements that will result in high, expected and low capacity requirements; that is, a lesser technological improvement will result in a higher capacity requirement.

G.4 ESTIMATES OF CAPACITY REQUIREMENTS

Estimate of capacity requirements are presented in Tables G-2 through G-4, and the following points should be considered when reviewing these forecasts:

a. Forecasts are in equivalent 36 MHz transponders to facilitate comparison with potential and actual capacities.

b. High, expected and low estimates of demand or capacity requirements were developed as follows:

   1. High estimate - Low percentage removed for common carrier consideration (see Appendix F) Low estimate of analog modulation improvement
   2. Expected estimate - Expected percentage removed for common carrier consideration. Expected analog modulation improvement
   3. Low estimate - High percentage removed for common carrier consideration. High estimate of analog modulation improvement

c. All other technology considerations (i.e., KBPS/HVS (i.e., half voice circuit), #MBPS/Trans, Percent on Analog/Digital) were the same for all three estimates.

d. These high and low estimates are not the same as the confidence intervals which dealt with levels of confidence in making the baseline forecasts. The confidence intervals, if incorporated here, would simply widen the ranges indicated by the highs and lows.

The actual conversion of voice, data and video forecasts to equivalent transponders involved the following considerations:

a. Voice - Consider:

   1. Percent on analog and on digital by year
   2. For percent on analog: - # HVC/Transponder; by year
   3. For percent on digital: X # KBPS/HVC; - # MBPS/Transponder; by year

b. Data - Consider: - # MBPS/Transponder; by year

c. Video - Consider: Net addressable already expressed in equivalent 36 MHz transponders.

The information in Tables G-2 through G-4 is graphed in Figure G-1 to indicate the high, expected and low estimates of required capacity over time. Estimates of capacity requirements by band are presented in Tables G-5 through G-7. These forecasts were calculated in preparation for Task 2.0, and they correspond to Tables F-21 through F-23 in Appendix F.

TABLE G-1. ESTIMATES OF SELECTED TECHNOLOGICAL CHANGES THROUGH 2000

	1980	1990	2000
# Half Voice Circuits/36 MHz Transponder (Function of frequency and amplitude modulation techniques)			
Estimate # 1 (High Requirement)	1200	2400	4800
Estimate # 2 (Expected Requirement)	1200	3000	6000
Estimate # 3 (Low Requirement)	1200	3600	7200
# KBPS/Half Voice Circuit (Function of Coding Techniques - three estimates are the same)			
Estimate # 1 (High Requirement)	64	32	24
Estimate # 2 (Expected Requirement)	64	32	24
Estimate # 3 (Low Requirement)	69	32	24
# MBPS/36 MHz Transponder (Function of digital modulation techniques - three estimates are the same)			
Estimate # 1 (High Requirement)	60	90	90
Estimate # 2 (Expected Requirement)	60	90	90
Estimate # 3 (Low Requirement)	60	90	90
% Voice on Analog/Digital (Function of trends - three estimates are the same)			
Estimate # 1 (High Requirement)			
Analog	100	75	50
Digital	0	25	50
Estimate # 2 (Expected Requirement)			
Analog	100	75	50
Digital	0	25	50
Estimate # 3 (Low Requirement)			
Analog	100	75	50
Digital	0	25	50

TABLE G-2. MAXIMUM NET ADDRESSABLE, HIGH ESTIMATE IN TRANSPONDERS

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (Residential)	3.5	77.2	282.9
MTS (Business)	9.0	244.6	946.1
Private Line	174.9	451.6	1031.2
Mobile	0.4	6.6	17.3
Public Radio	0.3	0.7	0.6
Commercial and Religious	0.4	0.8	0.8
Occasional	0.7	0.7	0.7
CATV Music	0.1	0.1	0.3
Recording	0.0	0.0	0.1
TOTAL	189.3	782.3	2279.9
DATA			
Data Transfer	0.0	0.4	2.9
Batch Processing	0.1	0.7	1.7
Data Entry	9.1	68.1	121.5
Remote Job Entry	0.2	7.7	18.0
Inquiry/Response	0.1	3.5	8.7
Timesharing	0.1	0.9	2.0
USPS/EMSS	0.0	0.6	2.0
Mailbox	0.0	0.5	1.0
Administrative Messages	2.2	37.7	105.7
Facsimile	0.5	4.3	5.6
Communicating Word Processors	0.0	0.3	1.0
TWX/TELEX	0.0	0.2	0.2
Mailgram/Telegram/Money Orders	0.0	0.0	0.0
Point of Sale	0.1	4.3	6.9
Videotext/Teletext	0.0	1.9	8.6
Telemonitoring Service	0.0	0.0	0.0
Secure Voice	0.0	0.2	1.9
TOTAL	12.5	131.2	287.7
VIDEO			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel	0.0	0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE G-3. MAXIMUM NET ADDRESSABLE, EXPECTED ESTIMATE, IN TRANSPONDERS

SERVICE	YEAR 1980	YEAR 1990	YEAR 2000
VOICE			
MTS (Residential)	3.5	50.6	193.7
MTS (Business)	9.0	160.3	647.7
Private Line	174.9	382.9	946.0
Mobile	0.4	5.6	15.8
Public Radio	0.3	0.6	0.6
Commercial and Religious	0.4	0.7	0.7
Occasional	0.7	0.6	0.6
CATV Music	0.1	0.1	0.3
Recording	0.0	0.0	0.1
TOTAL	180.3	601.4	1805.6
DATA			
Data Transfer	0.0	0.4	2.7
Batch Processing	0.1	0.7	1.6
Data Entry	9.1	62.5	114.0
Remote Job Entry	0.2	7.1	6.9
Inquiry/Response	0.1	3.2	8.2
Timesharing	0.1	0.8	1.9
USPS/EMSS	0.0	0.6	1.8
Mailbox	0.0	0.4	1.0
Administrative Messages	2.2	34.6	99.2
Facsimile	0.5	3.9	5.3
Communicating Word Processors	0.0	0.3	0.9
TWX/TELEX	0.0	0.1	0.2
Mailgram/Telegram/Money Orders	0.0	0.0	0.0
Point of Sale	0.1	4.0	6.5
Videotext/Teletext	0.0	1.8	8.1
Telemonitoring Service	0.0	0.0	0.0
Secure Voice	0.0	0.2	1.8
TOTAL	12.5	120.4	269.9
VIDEO			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel	0.0	0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE G-4. MAXIMUM NET ADDRESSABLE, LOW ESTIMATE, IN TRANSPONDERS

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (Residential)	3.5	34.9	120.1
MTS (Business)	9.0	110.7	401.8
Private Line	174.9	337.2	889.3
Mobile	0.4	4.9	14.9
Public Radio	0.3	0.5	0.6
Commercial and Religious	0.4	0.6	0.7
Occasional	0.7	0.6	0.6
CATV Music	0.1	0.1	0.3
Recording	0.0	0.0	0.1
TOTAL	189.3	489.5	1428.4
DATA			
Data Transfer	0.0	0.4	2.5
Batch Processing	0.1	0.6	1.5
Data Entry	9.1	56.9	106.5
Remote Job Entry	0.2	6.4	15.8
Inquiry/Response	0.1	2.9	7.6
Timesharing	0.1	0.7	1.8
USPS/EMSS	0.0	0.5	1.7
Mailbox	0.0	0.4	0.9
Administrative Messages	2.2	31.5	92.6
Facsimile	0.5	3.6	4.9
Communicating Word Processors	0.0	0.2	0.9
TWX/TELEX	0.0	0.1	0.2
Mailgram/Telegram/Money Orders	0.0	0.0	0.0
Point of Sale	0.1	3.6	6.0
Videotext/Teletext	0.0	1.6	7.6
Telemonitoring Service	0.0	0.0	0.0
Secure Voice	0.0	0.2	1.6
TOTAL	12.5	109.7	252.1
VIDEO			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel	0.0	0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE G-5
C-BAND NET ADDRESSABLE, EXPECTED ESTIMATE, IN TRANSPONDERS

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (Residential)	3.5	50.6	137.3
MTS (Business)	9.0	160.3	460.4
Private Line	174.9	382.9	671.3
Mobile	0.4	5.6	11.3
Public Radio	0.3	0.6	0.6
Commercial and Religious	0.4	0.7	0.7
Occasional	0.7	0.6	0.6
CATV Music	0.1	0.1	0.3
Recording	0.0	0.0	0.1
TOTAL	189.3	601.4	1282.6
DATA			
Data Transfer	0.0	0.4	2.5
Batch Processing	0.1	0.6	1.4
Data Entry	9.1	60.6	91.8
Remote Job Entry	0.2	6.9	15.6
Inquiry/Response	0.1	3.2	8.2
Timesharing	0.1	0.8	1.9
USPS/EMSS	0.0	0.5	1.5
Mailbox	0.0	0.4	0.8
Administrative Messages	2.2	33.6	80.2
Facsimile	0.5	3.8	4.3
Communicating Word Processors	0.0	0.3	0.7
TWX/TELEX	0.0	0.1	0.1
Mailgram/Telegram/Money Orders	0.0	0.0	0.0
Point of Sale	0.1	3.8	5.2
Videotext/Teletext	0.0	1.7	6.5
Telemonitoring Service	0.0	0.0	0.0
Secure Voice	0.0	0.2	1.5
TOTAL	12.5	116.8	222.0
VIDEO			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel	0.0	0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE G-6
KU-BAND NET ADDRESSABLE, EXPECTED ESTIMATE, IN TRANSPONDERS

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (Residential)	2.5	48.1	193.7
MTS (Business)	6.4	152.6	647.7
Private Line	124.9	364.5	946.0
Mobile	0.3	5.3	15.8
Public Radio	0.3	0.6	0.6
Commercial and Religious	0.4	0.7	0.7
Occasional	0.7	0.6	0.6
CATV Music	0.1	0.1	0.3
Recording	0.0	0.0	0.1
TOTAL	135.7	572.5	1805.6
DATA			
Data Transfer	0.0	0.4	2.7
Batch Processing	0.0	0.7	1.6
Data Entry	6.2	61.6	114.0
Remote Job Entry	0.2	7.0	16.9
Inquiry/Response	0.0	1.3	4.1
Timesharing	0.0	0.3	0.8
USPS/EMSS	0.0	0.6	1.8
Mailbox	0.0	0.4	1.0
Administrative Messages	1.5	34.1	99.2
Facsimile	0.3	3.9	5.3
Communicating Word Processors	0.0	0.3	0.9
TWX/TELEX	0.0	0.1	0.2
Mailgram/Telegram/Money Orders	0.0	0.0	0.0
Point of Sale	0.1	3.9	6.5
Videotext/Teletext	0.0	1.7	8.1
Telemonitoring Service	0.0	0.0	0.0
Secure Voice	0.0	0.2	1.8
TOTAL	8.5	116.4	264.7
VIDEO			
Network	10.0	42.9	42.0
CATV	34.0	82.4	68.2
Occasional	14.3	41.6	36.0
Recording Channel	0.0	0.0	1.3
Teleconferencing	3.0	155.9	245.3
TOTAL	61.3	322.8	392.7

TABLE G-7
KA-BAND NET ADDRESSABLE, EXPECTED ESTIMATE, IN TRANSPONDERS

SERVICE	YEAR 1980	1990	2000
VOICE			
MTS (Residential)		48.4	142.8
MTS (Business)		153.6	478.1
Private Line		366.9	697.2
Mobile		5.3	11.7
Public Radio		0.4	0.4
Commercial and Religious		0.5	0.5
Occasional		0.4	0.4
CATV Music		0.1	0.3
Recording		0.0	0.1
TOTAL		575.7	1331.5
DATA			
Data Transfer		0.4	2.5
Batch Processing		0.7	1.6
Data Entry		62.5	111.3
Remote Job Entry		7.1	16.3
Inquiry/Response		0.5	1.6
Timesharing		0.1	0.3
USPS/EMSS		0.6	1.8
Mailbox		0.4	1.0
Administrative Messages		34.6	96.9
Facsimile		3.9	5.1
Communicating Word Processors		0.3	0.9
TWX/TELEX		0.1	0.2
Mailgram/Telegram/Money Orders		0.0	0.0
Point of Sale		4.0	6.3
Videotext/Teletext		1.8	7.9
Telemonitoring Service		0.0	0.0
Secure Voice		0.2	1.7
TOTAL		117.1	255.5
VIDEO			
Network		30.0	29.4
CATV		57.7	47.7
Occasional		29.1	25.2
Recording Channel		0.0	0.9
Teleconferencing		132.6	208.5
TOTAL		249.4	311.7

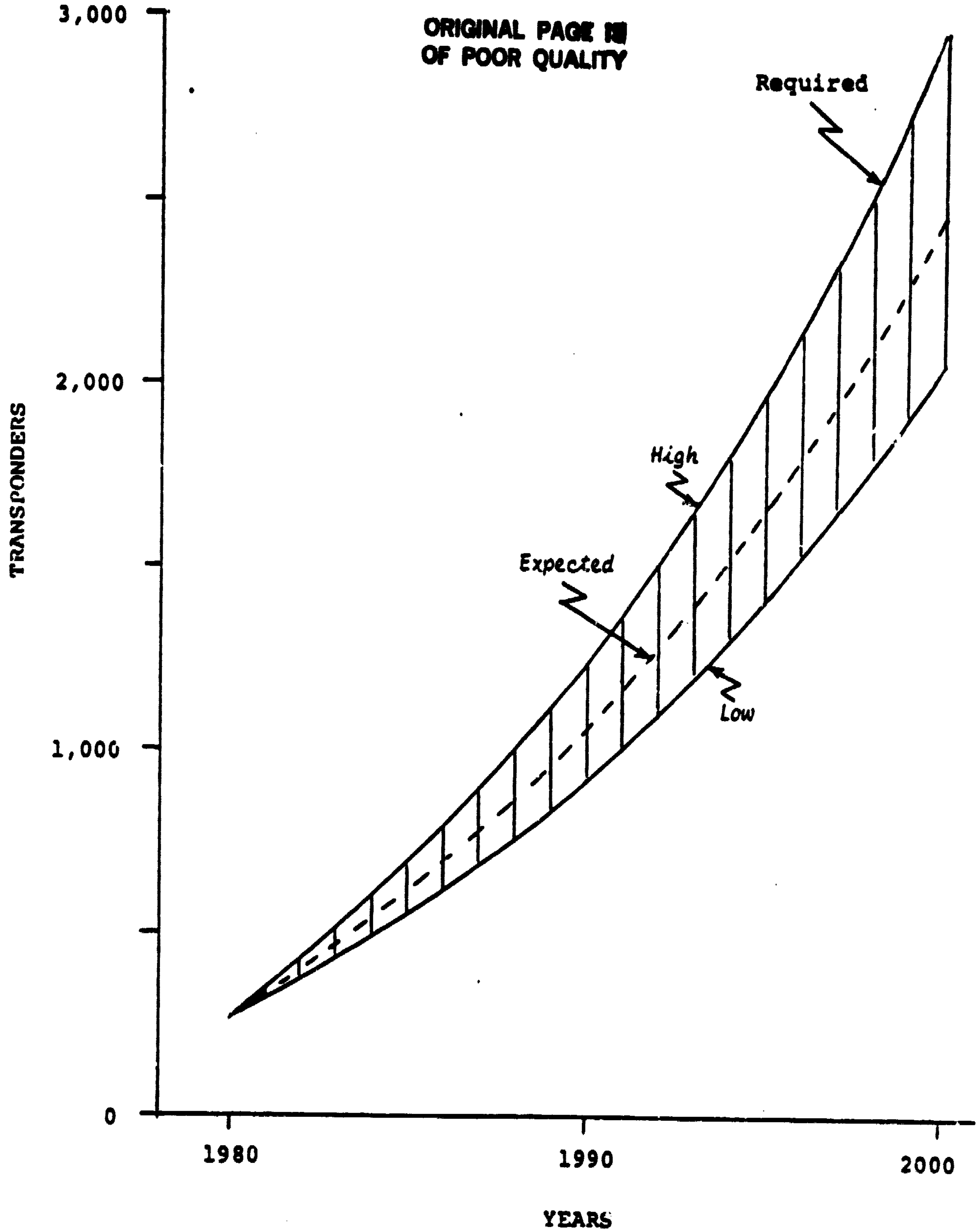


FIGURE G-1. HIGH, EXPECTED AND LOW ESTIMATES OF REQUIRED CAPACITY

ANNEX 1 TO APPENDIX G
REPORT ON IMPROVING SPECTRUM UTILIZATION

Due to the prevailing crowded conditions in many regions of the radio spectrum and increased demand for the future, communications requirements have created a need for improved spectrum utilization. In order to improve the spectrum utilization, the following techniques are under consideration:

a. Bandwidth efficient modulation techniques
b. Reduced satellite spacing
c. Frequency reuse (multibeam antennas and polarization techniques).

1.1 MODULATION TECHNIQUES

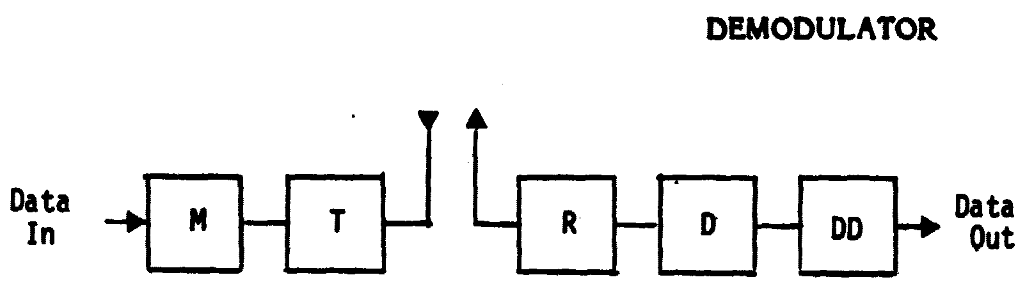
An intelligent application of an efficient digital modulation technique provides one means of achieving improved spectral efficiency. The selection of the modulation scheme should be compared with respect to ideal performance, spectral properties, signaling speed, complexity and the effects of interference on performance, fading and delay distortion.

1.1.1 Description of the Representative Modulation Schemes

There are three basic modulation techniques: Amplitude Modulation (AM), Frequency Modulation (FM) and Phase Modulation (PM). Each of these basic techniques has a large number of variants. In recent years, hybrid schemes (e.g., amplitude-and-phase-shift-keying-APK) have received increased attention because of their inherent economical use of bandwidth.

The primary components of a system for transmitting digital data over a radio channel are illustrated below. All digital modulation schemes can be conceptualized in terms of radio frequency sinusoids (carriers) modulated by low frequency (baseband modulation) signals that convey the digital information. The baseband modulation signals may be filtered, weighted or otherwise shaped prior to modulating the carrier in order to achieve desirable results. At the receiver, the baseband information is recovered by a detection process. Coherent detection

requires a sinusoidal reference signal perfectly matched in both frequency and phase to the received carrier. This phase reference may be obtained either from a transmitted pilot tone or from the modulated signal itself. Noncoherent detection, being based on waveform characteristics independent of phase, does not require a phase reference.



M = Modulator, T = Transmitter, R = Receiver, D = Detector, DD = Decision Device

PRIMARY COMPONENTS OF RADIO CHANNEL

On receive side, the detection is followed by a decision process that converts the recovered baseband modulation signal into a sequence of digital bits. This process requires bit synchronization, which is generally extracted from the received waveform. With most modulation schemes, decisions can be made on a bit-by-bit basis with no loss in performance, but with some schemes an advantage can be gained by examining the signal over several bit intervals prior to making each bit decision. The portion of the received waveform examined by the decision device in making a single bit decision is called the observation interval.

The selection of a modulation technique should be based on the following requirements:

a. Bandwidth efficient
b. Constant envelope amplitude
c. Minimum adjacent channel interference and high immunity to inband interference
d. Minimum hardware complexity.

A brief description of the various properties of the modulation techniques is given below.

1.1.1.1 Amplitude Modulation (AM) Techniques

The simplest digital AM technique is double sideband (DSB) AM modulated by a binary signal. The double sideband waveform is represented as follows:

$$f_{DSB} = \frac{A}{2}(a + m(t)) \operatorname{Cos} w_c t$$

where,

$m(t)$ = is the modulating signal

w_c = is the carrier frequency

For the case of modulation by a non-return-to-zero (NRZ) binary data waveform $m(t) = \pm 1$, we have on-off-keying (OOK) modulation. Such an OOK waveform can be detected either coherently or noncoherently, but the difference in performance is slight compared to the required increase in complexity so that coherent decision of OOK is not employed over radio channels. The properties of the DSB waveform can be modified by replacing the NRZ m(t) by some other type of binary baseband signal e.g., the "partial response" signal (1).

Since the carrier conveys no information, the spectrum efficiency can be improved by the use of double sideband suppressed carrier (DSB - SC)AM. The general form of the DSB - SC signal is:

$$f_c = A\, m(t) \operatorname{Cos} w_c(t)$$

The double sideband technique involves the transmission of a redundant sideband. For applications in which spectral efficiency is important, the occupied bandwidth can be reduced by a factor of two by the use of single sideband (SSB) modulation. The single sideband is generated by the use of a bandpass filter to supress one of the sidebands.

Quadrature Amplitude Modulation (QAM) is another AM alternative. This technique involves summing two DSB - SC signals 90° apart in phase. A special case of QAM is quadrature partial response (QPR), which has been proposed for

use in the Canadian 8 GHz frequency band (2). All of these techniques required coherent detection.

1.1.1.2 Frequency Modulation (FM) Techniques

The simplest FM technique is frequency-shift-keying (FSK) involving binary signaling by the use of two frequencies separated by f HZ, where f, the frequency deviation is small compared to the carrier frequency, fc. With FSK schemes, it is common practice to specify the frequency spacing in terms of the modulation index, d, defined as:

$$d = \Delta f.T$$

where,

T = is the symbol duration

As with other modulation schemes, FSK can be detected either coherently or noncoherently.

Recently, considerable interest has arisen in modified versions of FSK, including some coherent schemes. These schemes are based on the idea of Continuous Phase FSK (CP FSK), in which the abrupt changes at the bit transition instants characteristics of other FSK implementations are avoided. This implementation of FSK results in rapid spectral roll-off and improved efficiency. The improvement is attained by the use of observation intervals greater than 1 bit (4). This feature enables narrower filter bandwidths that would otherwise be feasible. With coherent detection, values of D in the neighborhood of 0.7 have been shown to provide optimal performance for any observation interval (5).

Another FM technique that has received considerable interest in recent years is minimum-shift-keying (MSK), also called fast frequency-shift-keying, MSK is a special case of CP - FSK for which d = 0.5 and coherent detection is used. This technique achieves performance identical to coherent PSK and exhibits superior spectral properties of CP - FSK. MSK has the additional advantage of the possibility of a relatively self-synchronizing implementation (6), an advantage that coherent CP - FSK with modulation index 0.7 does not share.

1.1.1.3 Phase Modulation (PM) Techniques

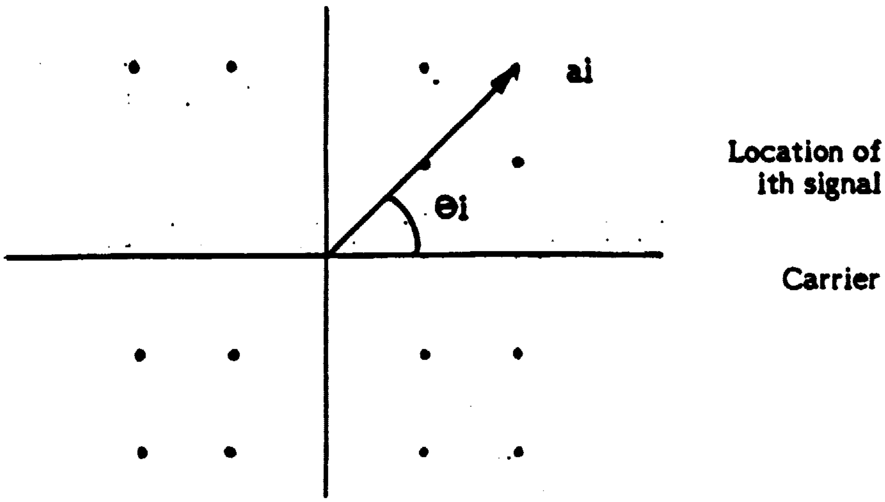
By definition, digital PM schemes require coherent detection. The most straight forward approach is coherent Binary Phase Shift Keying (BPSK), in which the carrier phase is shifted by 0 or 180 degrees. Detection requires a precise phase reference which is normally obtained by performing a non-linear operation on the received waveform. Since some phase reference extraction techniques exhibit 180° phase ambiguities, a modified form of PSK called Differentially Encoded PSK (DE - PSK) is often used. With DE - PSK, information is conveyed via transitions in carrier phase. Since a bit decision error on the current bit will include another error on the subsequent bit, the performance of DE - PSK is slightly inferior to that of coherent (DPSK), in which, as with DE - PSK, the information is differentially encoded. The difference between DPSK and DE - PSK lies in the detector. With DPSK, no attempt is made to extract a coherent phase reference for the current bit interval. Since the phase reference signal is not smoothed over many bit intervals, the performance of DPSK is somewhat worse than that of DE - PSK.

Another version of phase modulation is Quaternary PSK (QPSK) which involved encoding two bits at a time into one of four possible carrier phases spaced 90° apart. As in the binary case, the data can be differentially encoded and differentially detected. A modified version of QPSK, called Staggered QPSK 9SQPSK) has come into use. This scheme offers advantages over conventional QPSK with regard to spectral efficiency, sideband regeneration and synchronization, (7,8,9,10). Higher order phase modulations, i.e., 8Ø and 16Ø are also being proposed for a more efficient use of the available spectrum. The performance characteristics of various phase modulations are given in Table 1-1. It is evident from the table that a much higher Eb/No is required as the higher order phase modulations are used. The higher phase modulations can, therefore, be used where sufficient EIRP is available to maintain the link performance.

1.1.1.4 Hybrid AM/PM Techniques

The ever increasing need for bandwidth conservation has led to the use of a class of hybrid AM/PM techniques called amplitude and phase-shift-keying (APK) (11).

The AM/PM can be visualized by the representation in a phase-amplitude signal space as illustrated below.



$Si(t) = Ai \, Cost \, (wt + \Theta i) : i \pm 1, 2, \ldots 16$

LOCATION OF 16 - ary APK WAVEFORMS IN PHASE AMPLITUDE SPACE

The above figure shows the signal space location of each of the 16 possible transmitted signals for 16 - ary APK.

The modulation schemes with respect to their performance under a variety of conditions characteristic of digital radio channels are compared in Table 1-1. A performance measure utilized for comparison is the baseband equivalent Eb/No required to achieve a bit error rate of 10^{-4}. Of particular interest is the fact that CP - FSK over a 3-bit observation interval can outperform BPSK and other equivalent techniques (which are optimal only when the observation interval is confined to one bit). The identical ideal performance of QAM, MSK, and QPSK attests to their underlying similarities discussed in the literature (12,13). Indeed, offset-keyed QAM (7). MSK, SQPSK differ only in the weighting functions applied to the I & Q channels.

1.1.2 Spectral Characteristics

The spectral characteristics of the modulation schemes can be compared in many ways. Of particular interest is the extent to which a signal will interfere with

signals in adjacent channels. One measure of this quality is the alternation of a signal's power spectrum at a specified distance from the center frequency. If, for example, we examine the alternation at an arbitrary distance of $^8/T$ from the center frequency (T is the signal period), we find that with AM modulation the sidelobes are down by about 25 dB, and with PM schemes the sidelobes are down by about 33 dB, and with continuous phase FM the sidelobes are down by about 33 dB, and with continuous phase FM the sidelobes are down by 60 dB or more. In general, for frequencies far from the center frequency (large (f-fc)T), the spectrum of AM and PM signals fall off as f^{-2} while that of CP - FM signals fall off as f^{-4}.

Another spectral property of interest is the bandwidth required to transmit at a specified information rate. The quantity number of bits per hertz $^R/W$, where R is the data rate and W is the IF bandwidth for a modulation technique is an important figure of merit. Table 1-1 shows the speed for each technique together with the Eb/No required for 10^{-4} BER.

1.1.3 Effects of Interference

An important factor in evaluating potential modulation schemes for digital radio is the effects of co-channel and adjacent interference. We have already discussed one aspect of adjacent channel interference - the out-of-band alternation of the various schemes. It was pointed out that MSK and other CP -FSK schemes enjoy a large advantage over the AM and PM schemes, when no post modulation filtering is employed. Another aspect of adjacent channel interference is the amount of performance degradation caused by a specified level of interference. Of the schemes for which data are available, noncoherent FSK and BPSK show the least degradation from ideal performance, while the 8-ary and 16-ary schemes exhibit the most degradation.

1.1.4 References

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TABLE 1-1. IDEAL PERFORMANCE OF REPRESENTATIVE MODULATION SCHEMES

Type	Modulation Scheme	Eb/No (dB)	Speed (bits/S/Hz)
AM	OOK - coherent detection	11.4	0.8
	OOK - envelope detection	11.9	0.8
	QAM	8.4	1.7
	QPR	10.7	2.25
FM	FSK - Noncoherent Mod Index = 1	12.5	0.8
	CP - FSK - Coherent Detection Mod Index = 0.7	7.4	0.8
	CP - FSK - Noncoherent Detection Mod Index = 0.7	9.2	1.0
	MSK Mod Index = 0.5	8.4	1.9
	MSK - Differential Encoding Mod Index = 0.5	9.4	1.9
PM	BPSK	8.4	0.8
	DE - BPSK	8.9	0.8
	DPSK	9.3	0.8
	QPSK	8.4	1.9
	DQPSK	10.7	1.8
	SQPSK	8.4	1.8
	80 - PSK	11.8	2.6
	160 - PSK	16.2	2.9
AM/PM 16 - Ary APK		12.4	3.1

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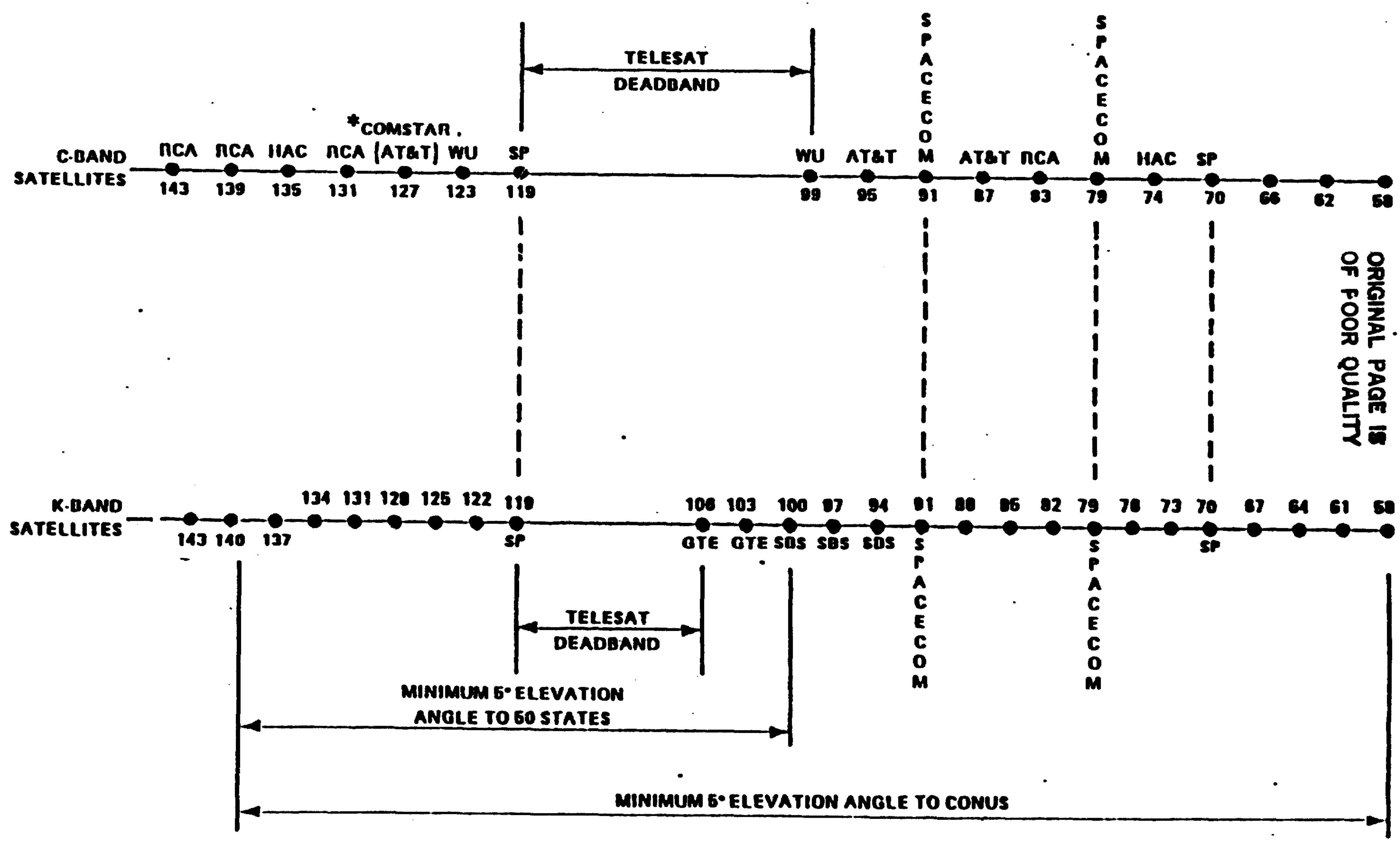
1.2 REDUCED SATELLITE SPACING

1.2.1 Demand For Slots and Spacing

Due to the increasing demand for orbital slots, FCC is planning on reducing orbital spacing between the satellites. Satellite spacing could be reduced from the current 4° between C-Band satellites and 3° between Ku-Band satellites to 2° between all satellites, thereby making mor orbital positions available. Preliminary studies indicate that three degree separation for C-Band satellites is within the state-of-the-art. However, two degree separation for C and Ku-Band will require technological advances in antenna design. Figures 1-1 through 1-3 show the locations for currently authorized satellites at 4 and 3 degrees for C and Ku-Bands and possible locations if the satellite spacing is reduced to 2 degrees. The locations in the orbital arc with 5° or greater elevation angles are based upon a study conducted by NASA for FCC.

If the FCC directs a 3 degree spacing between all requested satellites, then there will not be enough locations for C-Band satellites that can view the CONUS with a minimum of 5 degree earth station elevation angle. With the present 4° spacing 18 orbital slots are available between the arc from 58° to 143° with 20° deadband from 99° to 119° for Canada. With 3° proposed separation 23 orbital slots will be available in the same orbital arc. With two degree spacing for C-Band satellites, 31 orbital slots are available from 58° to 138° with 20° deadband for Canada. However, with 2 degree spacing, all requirements for satellites can be accommodated, with the 5 degree elevation angle criteria. In all approaches, there are many Ku-Band satellite locations available at present. Based on the number of filings with FCC there appears to be no urgent need to go to 2° spacing for Ku-Band satellites. Furthermore, the South American countries - Brazil, Columbia and Mexico, have expressed interest in launching their own satellite communication systems. Although the proposed systems would be located in the portion of the arc sought by some U.S.

ORBITAL LOCATIONS WITH 4° C-BAND SPACING, 3° K-BAND SPACING



*UNTIL END OF 1982

FIGURE 1-1

ORBITAL LOCATIONS WITH 2° C-BAND SPACING, 2° K-BAND SPACING

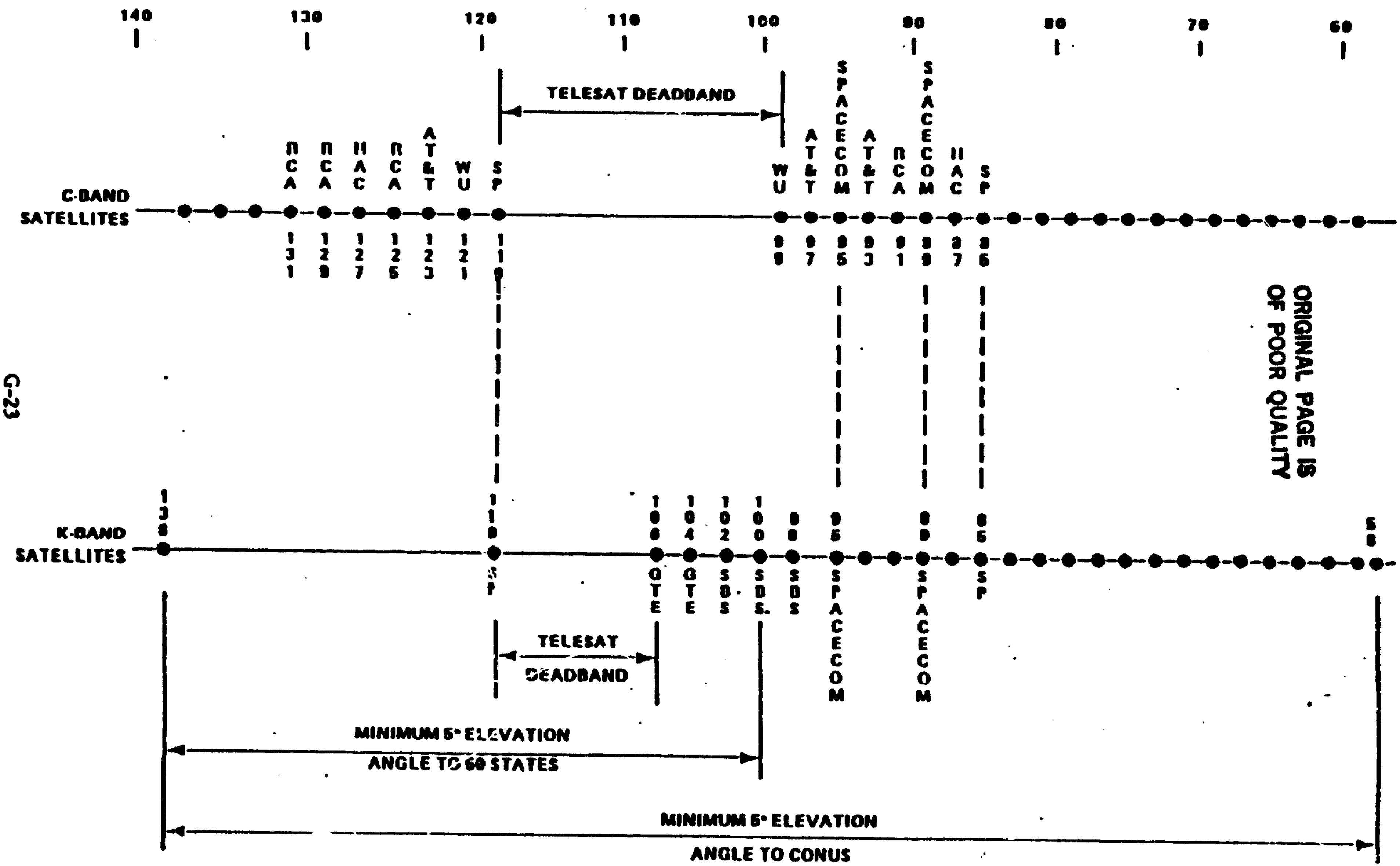


FIGURE 1-2

ORBITAL LOCATIONS WITH 3° C-BAND SPACING

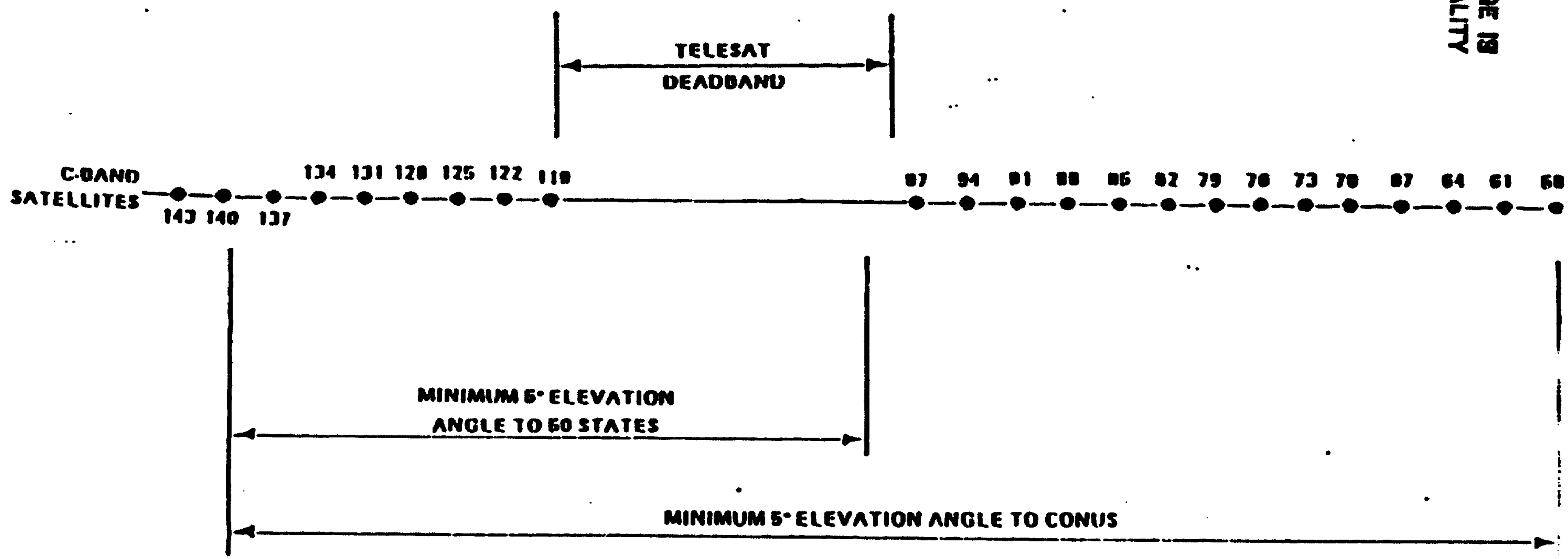


FIGURE 1-3

companies (Brazil at 60° and 67.5°, Columbia at 72.5°) there is general consensus that because the satellites would beam signals outside CONUS, normal 4° spacing will not be required at U.S. and South American satellites could be colocated. However, FCC wants to use arc from 55°-70° West only when all other available slots are occupied.

Domestic satellite traffic can be classified into two broad categories, each having unique interference considerations:

a. Single saturated carrier using the full transponder bandwidth and/or power, e.g., Frequency Modulation TV for broadcast and cable applications, FM multiplexed voice and high speed data up to 60MBPS.

b. Multiple carrier-per-transponder in which a number of signals simultaneously occupy a transponder. The multiple carrier-per-transponder may consist of two video channels per transponder or 20 to 30 moderate size carriers or hundreds of SCPC carriers at very low power levels.

An important characteristic of a signal is its power spectral density. The higher the power spectral density, more resistent is the signal to interference. The higher spectral density also increases its interfering effect on other signals. Generally, full transponder signals have the highest power density and SCPC signals the lowest. Due to small power density of SCPC signals, they are the most susceptible to interference from signals in the adjacent spacecrafts as satellite spacing is reduced. By proper frequency coordination, the interference problem from the adjacent spacecraft can be minimized.

As orbital spacing is reduced, interference between traffic on satellites increase. Thus, how close domestic satellites can be placed relative to one another is a function of the level of interference that can be tolerated by the many different kinds of signals being carried. The two critical issues are:

a. What is the expected level of interference at reduced spacing?

b. What is the minimum carrier-to-interference ratio from all external sources which will insure satisfactory performance of a given service?

The first is primarily determined by the characteristics of the earth station antennas now operating with domestic satellites. The second is a complex function of the technical features of the transmission characteristics such as type of modulation, size and number of carriers, etc., used by satellite systems.

The design of a satellite communications link involves the allocation of a transponder's power and bandwidth to provide a desired signal quality to a customer. This task is accomplished within the constraints imposed by earth station antenna diameter, system noise temperature, modulation technique and economic considerations, etc. The two basic degradations to performance which must be overcome are noise and interference.

Historically, noise has been the primary design consideration. Thermal noise, which is inherent to all electrical devices has been, and continues to be, the limiting factor. However, when more than one signal occupies a transponder, intermodulation noise arising from the non-linear operation of the transponder becomes significant. These noise contributions can be controlled.

Satellite systems are subject to three major interference sources:

a. Energy spilled from adjacent cross-polarized transponders

b. Energy spilled from existing microwave system

c. Energy spilled from adjacent co-frequency transponders.

The level of interference caused by co-frequency channels is largely determined by earth station antenna size.

The mechanism co-frequency interference due to adjacent satellites is illustrated below. There are two contributing factors.

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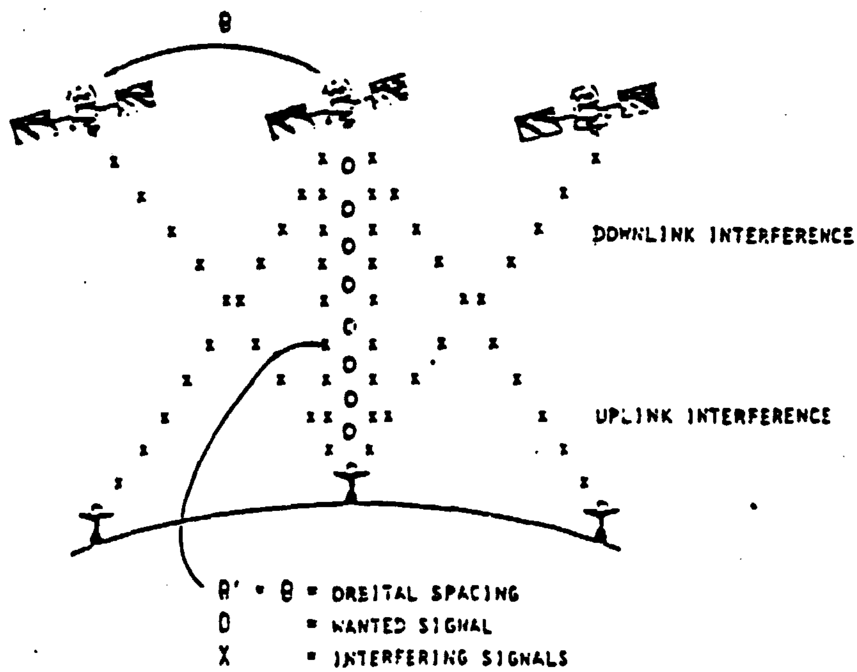
a. Uplink interference occurs due to the finite gain of sidelobes in the direction of an adjacent satellite illuminating the receive antenna of the wanted satellite. The energy from the unwanted sources is reradiated into the receiving earth station.

b. Downlink interference occurs by virtue of the finite gain of the receiving antenna in the direction of an adjacent satellite which picks up the energy from the unwanted sources.

INTERFERENCE MECHANISMS



Clearly, the antenna characteristics play an important part in transponder which is horizontally polarized. If the corresponding transponder on the adjacent satellite is vertically polarized, the gain in that direction is given by the lower curve. Thus, for a given angular separation the gain is lower, the interference is lower, and the satellites can be placed closer together.

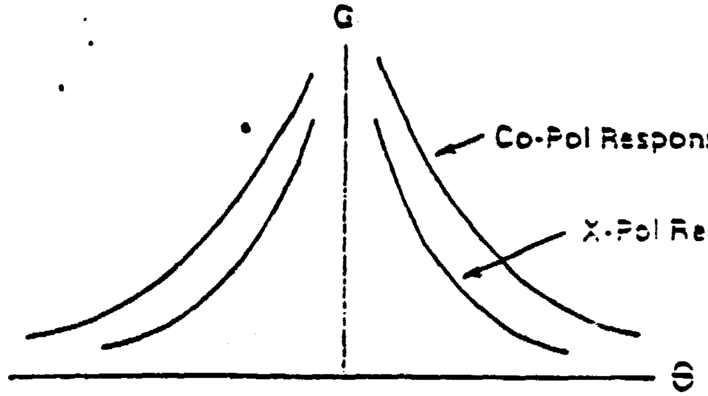
Off-axis cross-polarization discrimination of earth stations in the past has been estimated to be 4 to 6 dB, though it may be in the range of 10 to 15 dB for modern antennas; often one way of minimizing the effects of reduced spacing. Due to the frequency reuse using horizontal and vertical polarization, by interleaving the transponder polarization on uplink and downlink of the adjacent satellites, the adjacent satellite interference can be substantially reduced. The calculations indicate that significant technological improvements are required to exceed the FCC minimum requirements for 2^{o} spacing for C-Band satellites. Although 3 degree spacing will degrade the performance, there are indications that performance requirements can be met with existing satellites and earth stations in minimizing the effects of unwanted interference. The sidelobe reduction so as to increase the earth station discrimination i.e., the ratio in dB between the maximum on-axis gain and gain at a given angle off-axis will require further technological improvements.

1.2.2 Antenna Characteristics and Transponder Coordination

In accordance with FCC requirements, the co-polarized response is given by a 32-25 log θ, where θ is the angle from boresight (see figure below). As θ increases, i.e., as separation of satellites increases, the response in that direction decreases or equivalently the adjacent satellite interference reduces. The analog situation prevails on uplink where satellite is the receiving system and the interferences are earth stations.

The lower curve in the figure is the response of two cross-polarized signals in an adjacent spacecraft. The difference between the two curves is the off-axis cross-polarization discrimination. Since the new generation of satellites uses both horizontal and vertical polarization, proper transponder coordination can reduce the adjacent satellite interference significantly. For example, the

desired earth station may be receiving, from a particular transponder which is horizontally polarized. If the corresponding transponder on this adjacent satellite is vertically polarized, the gain in the direction of that satellite is given by the lower curve. Thus, for a given angular separation the gain is lower, the interference is lower, therefore the satellites can be placed closer than before.



θ = Angle Off-Axis

1.2.3 Recommendations and Conclusions

Two degree spacing for both C and Ku-Band satellite systems requires technological improvements in earth station antenna design. The possiblity of obsolescence of existing facilities must be evaluated against the availability of increased orbital slots. Preliminary studies indicate acceptable degradation in performance. Three degree separation at Ku-Band will require technical improvements in antenna design. Intuitively, the problem will be less severe compared to C-Band due to narrower beams of Ku-Band earth station antennas of equal size.

The proposed 3° orbital separation will result in acceptable degradation of performance. Various studies indicate a uniform 2° spacing can be phased in only as new technology develops sometime in the 1990s.

The possibility of non-uniform spacing of satellites, e.g., using 2, 3, or 4 degree spacing depending on the traffic characteristics may prove to be feasible in order to provide more orbital slots.

Two degree spacing for C and Ku-Band will require technological improvements. The economic impact of obsolescence of existing facilities against availability of increased number of orbital slots with 2^{o} separation will require a careful analysis. Studies performed by various manufacturers suggest that with 2^{o} separation with existing earth station technology some problems in performance might be encountered.

Standardization of spacecraft frequency and polarization plans, combined with off-axis polarization discrimination in existing earth station antennas offer a means of recovering lost system margins.

1.3 FREQUENCY REUSE (MULTIBEAM ANTENNAS AND POLARIZATION TECHNIQUES)

Frequency spectrum conservation is a key element in the design of a multibeam satellite antenna. The basic problem in a multibeam antenna design is the selection of a beam topology plan which optimally meets the desired system objectives of maximum frequency reuse and maximum isolation. The beam topology provides a plan in which number, call size, relative location, frequency band and polarization assignment of individual component beams are arranged in a given manner. The beam topology itself is not concerned with the physical implementation, but the evaluation of a specific topology plan does require the knowledge of physicaliy realizable radiation characteristics.

At present, all C-Band satellites either in orbit or various stages of design have CONUS coverage. Due to the large antenna structure required to obtain narrow beams (beam width = 60 /d degrees, where is carrier wave length and d is diameter of the satellite antenna) will require substantial increase in payload weight. Therefore, multibeam C-band satellite antennas at present are not feasible. However, considerable work is being done for future multibeam C-Band antennas. In Ku-Band Western Union's Advanced WESTAR to be launched in early 1984 is the only multibeam (4 beams with 4 x 4 on-board switch) communication satellite. FCC filings indicate that other common carriers have opted for CONUS coverage. Advanced WESTAR beam topology is illustrated in Figure 1-4.

ADVANCED WESTAR K-BAND CONUS BEAM COVERAGE

WITH SATELLITE AT 99° WEST LONGITUDE

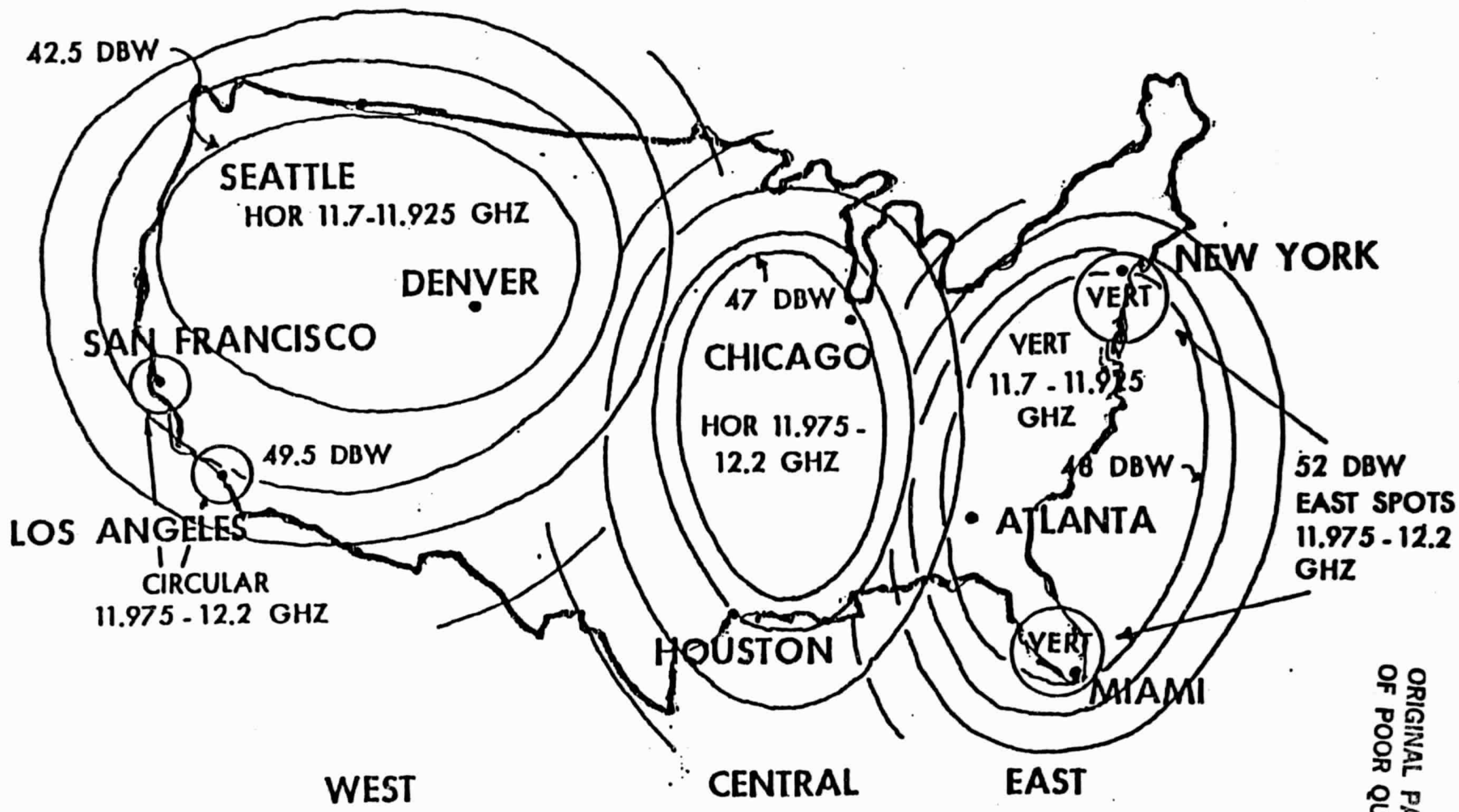


FIGURE 1-4. ADVANCED WESTAR BEAM TOPOLOGY

Ka-Band antennas are inherently multi-beam antennas. Extensive research and development effort is underway by Ford Aerospace and TRW to develop a multibeam Ka-Band satellite antenna for the Ka-Band demonstration satellite. The beam topology for non-contiguous coverage with beams pointed towards ten major cities is illustrated in Figure 1-5.

Possible beam topology plans can be divided into contiguous and non-contiguous plans. For the contiguous plans the sum of the shaped beam coverages cover the entire communications area. Such plans require the use of two orthogonal polarizations and/or the sub-division of the overall frequency band into sub-bands. Generally, not all the sub-bands are available in all the component beams. The non-contiguous plans can be operated with one polarization and one frequency.

The satellite throughput, ideally, is maximum when all the component beams have equal traffic. To maximize the frequency reuse advantage can be taken of unequal traffic distribution typical of CONUS usage to combine the lesser used beams. This has the effect of achieving the maximum frequency reuse and maximum antenna gain for those areas having the most traffic congestion. At the same time, the geographical areas having light traffic are illuminated with composite beams formed by combining beams with light traffic to form fewer beams having more traffic (and reduced antenna gain). The net result is reduced number of separate geographical areas requiring access-essentially reducing the on-board switch requirements. Note that spot beams still illuminate the North-Eastern seaboard, the upper Mid-West and the Los Angeles-San Francisco areas whereas the South and Northwest are illuminated by combined beams. The onboard switch requirement for complete interbeam connectivity in this case is reduced from 10 x 10 i.e., cross-point switches to 5 x 5 i.e., 25 cross-point switches. Figure 1-6 shows 10 component beams providing contiguous CONUS coverage. Figure 1-7 shows beam combining to reduce the geographical separation to five zones.

In a practical system, three or possibly four different slot bandwidths are desirable to accommodate different types of traffic. The present goal is to have 20 beam Ka-Band satellite antennas for the operational satellite to be launched in the late 1990s.

TRUNKING AND CPS COVERAGE

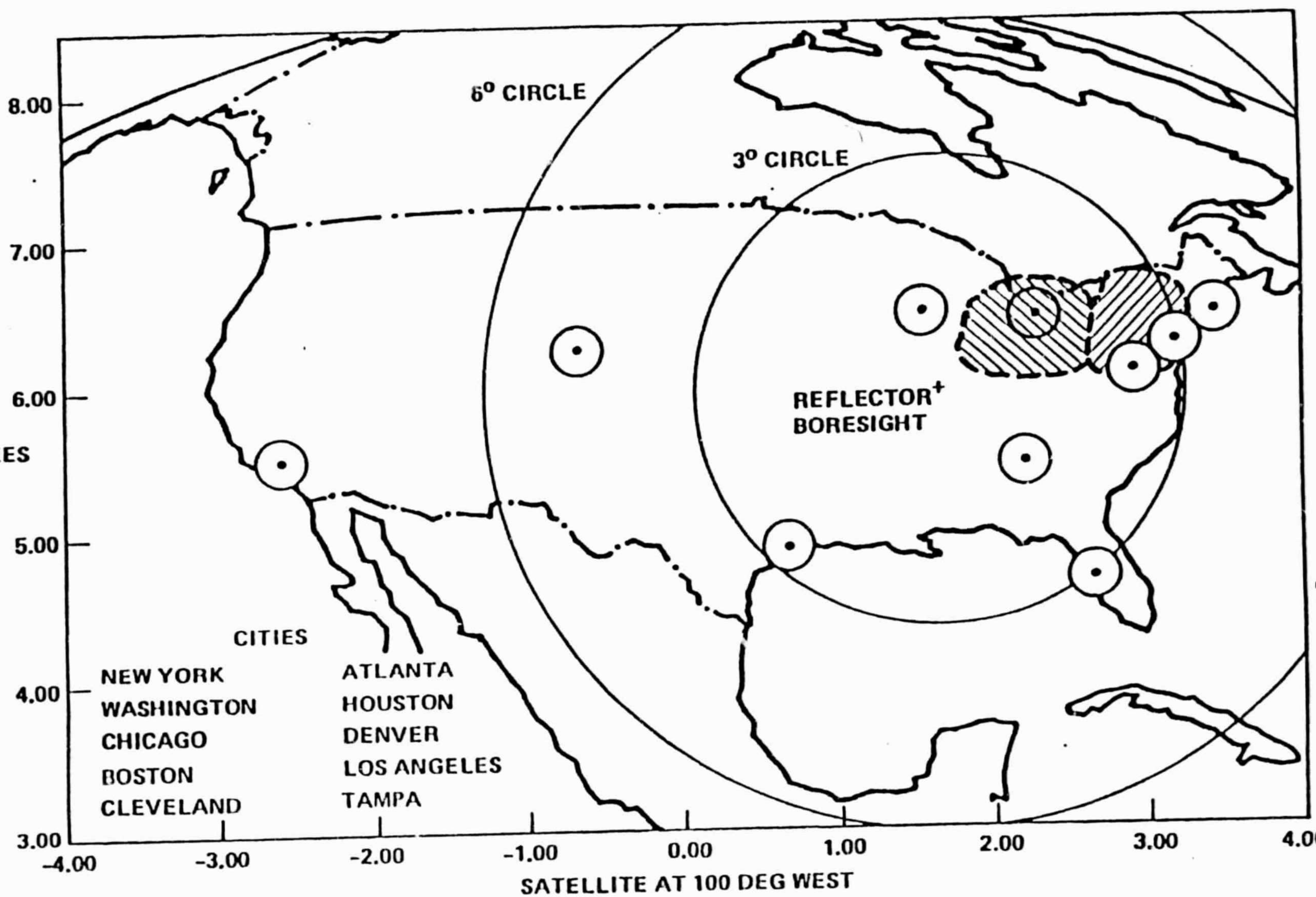


FIGURE 1-5. BEAM TOPOLOGY FOR NON-CONTIGUOUS COVERAGE

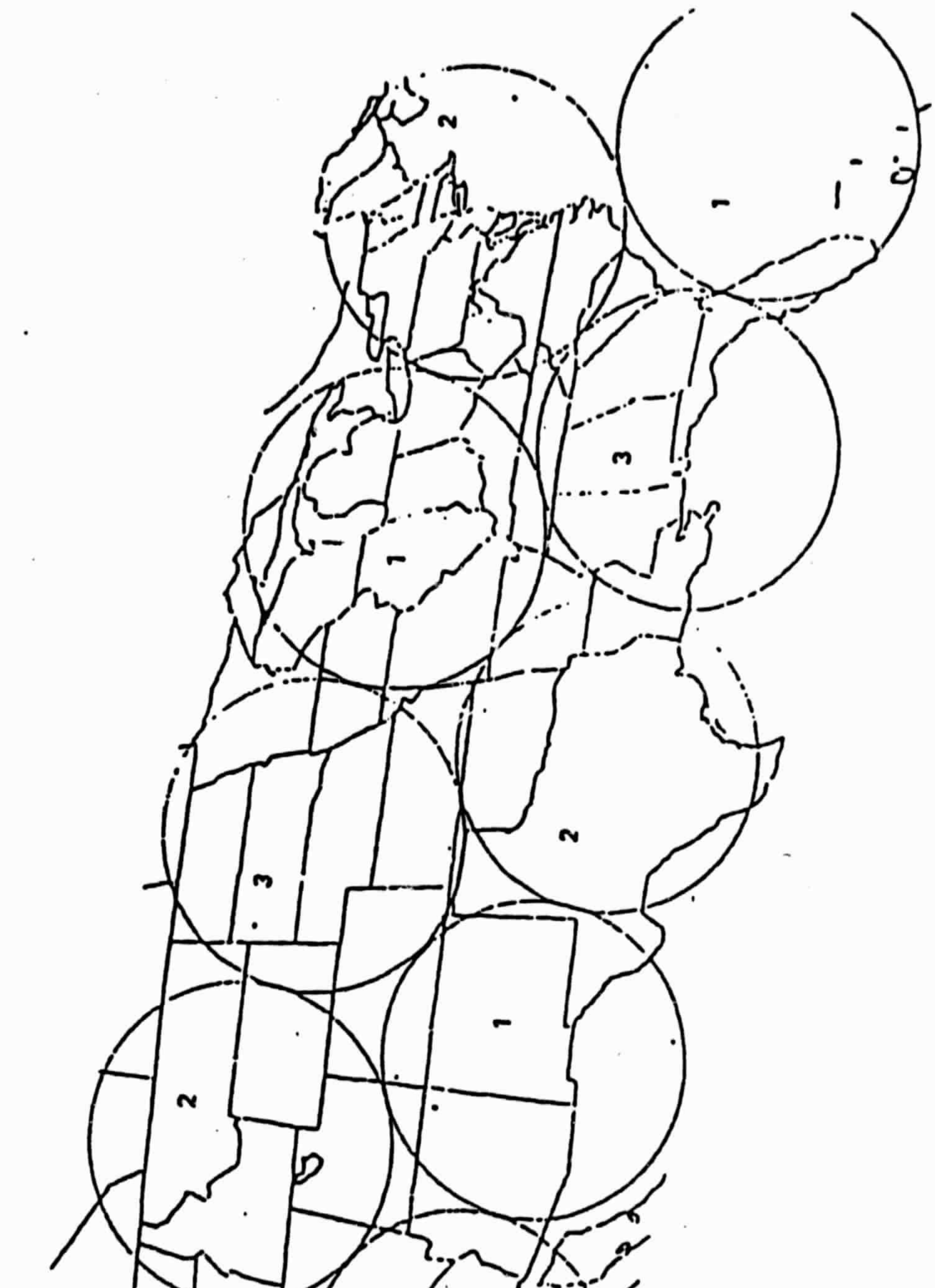


FIGURE I-6. TEN COMPONENT BEAMS

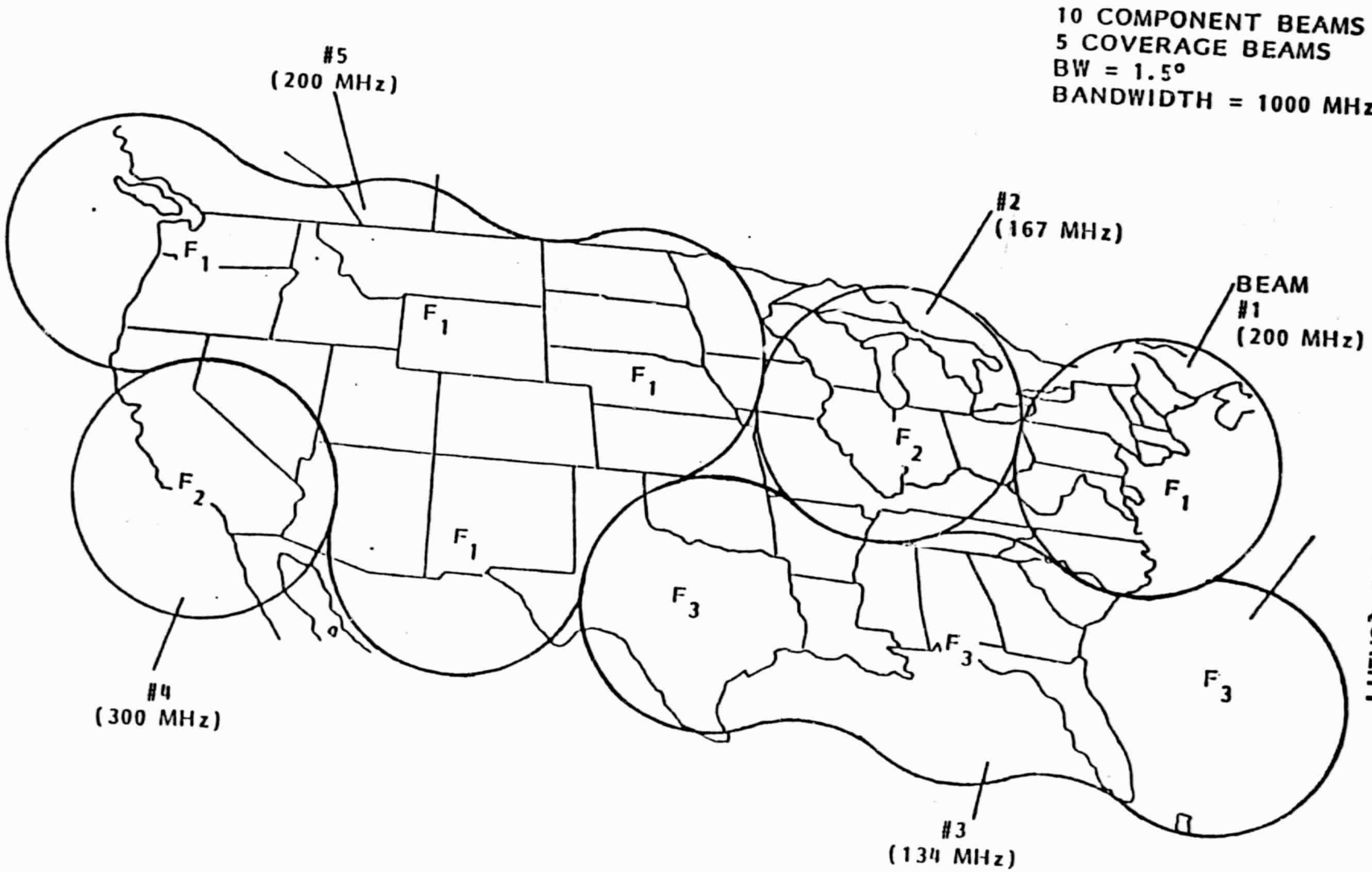


FIGURE 1-7. EXAMPLE 10 BEAM PATTERN REDUCED TO 5 GEOGRAPHICAL AREAS BY BEAM COMBINATION

1.4 SATELLITE THROUGHPUT CAPACITY

In the previous sections various methods to increase the satellite throughput were briefly discussed. It is becoming increasingly evident with the present 4 degree C-Band satellite spacing the present available slots will be filled up, unless other measures are taken to augment the available capacity to meet the increasing demand for communication requirements. Figures 1-1 through 1-4 show the location of C and Ku-Band satllites for various orbital separation. Maximum orbital capacity is estimated based on the number of available slots and frequency reuse and modulation techniques in the following section:

1.4.1 C-Band Throughput Capacity

The earlier generation of C-Band satellites like WESTAR I and II had twelve transponders each 40 MHZ wide with a useable bandwidth of 35 MHZ and 2 MHZ low and high guard band. The present trend however, is towards using dual polarization and the recent C-Band satellites have twenty-four transponders. The frequency reuse due to polarization immediately doubles the throughput capacity. Only recent SPCC has opted for six transponders, each 72 MHZ wide.

At present all C-Band satellites are placed 4 degrees apart in the orbit. Various reports suggested that a 3 degree spacing is quite feasible at the expense of acceptable amount of deterioration in performance. Other reports suggested that 2 degree separation will have an economic impact on the existing earth station.

Although C-Band multibeam antenna has attracted investigation and research efforts, no plans have been made to deploy a multibeam antenna. The deployment of multibeam antenna requires substantial increase in the aperture size and on-board switching capability resulting in significant satellite design changes and increase in the payloads. The total throughput is calculated as follows and the results are presented in Table 1-2.

TABLE 1-2. SATELLITE THROUGHPUT

	C-Band			Ku-Band		Ka-Band
	4° Spacing	3° Spacing	2° Spacing	3° Spacing	2° Spacing	2° Beam Contiguous CONUS Coverage @ 500 MBPS
Number of available slots	18	23	31	26	35	N/A
QPSK (dual polarization)	26 GBPS	33 GBPS	45 GBPS	39 GBPS	54 GBPS	10 GBPS
80 PSK (dual polarization)	39 GBPS	50 GBPS	67 GBPS	58 GBPS	78 GBPS	N/A
QPSK (single polarization)	N/A	N/A	N/A	19.5 GBPS	26.5 GBPS	N/A
80 PSK (dual polarization)	N/A	N/A	N/A	29 GBPS	39 GBPS	N/A

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1.4.1.1 Capacity Calculation

Case I: (a) 4° orbital separation, 24 transponders, 60 MBPS per transponder, QPSK modulation. Usable orbital arc from 58°W to 143°W, with 20° deadband from 99°W to 119° for Telesat.

Number of available slots	= 18
Total throughput	= 18 x 24 x 60 = 25,920 MBPS

(b) Same as (a) except 80, PSK modulation

Total throughput capacity	= 18 x 24 x 90 = 38,880 MBPS

Case II: (a) 3° orbital separate and same as (a) Case I

Number of available slots	= 23
Total throughput	= 23 x 24 x 90 = 33,120 MBPS

(b) Same as (a) except 80, PSK modulation

Total throughput capacity	= 23 x 24 x 90 = 49,680 MBPS

Case III: (a) 2° orbital separation, 24 transponders, 60 MBPS per transponder, QUSK modulation. Usable arc from 58°W to 138°W, with 20° deadband from 99°W to 119°W for Telesat.

Number of available slots	= 31
Total throughput capacity	= 31 x 24 x 66 = 44,640 MBPS

(b) Same as above, except 80, PSK modulation

Total throughput capacity	= 31 x 24 x 90 = 66,690 MBPS

1.4.2 Ku-Band Throughput Capacity

Due to expected depletion of C-Band orbital slots, more Ku-Band satellites are in various stages of operation and design. SBS-I and II are already in operation. SBS-I and II have 10 transponders each with 48 MHz bandwidth. Only a single polarization is used in these two satellites. Like C-Band dual polarization can be used to double the capacity. GTE's GSAT will have 8 transponders each with a bandwidth of 54 MHz on each polarization SPCC has opted for 6 transponders each with a bandwidth of 72 MHz. Western Union's Advanced WESTAR is a multibeam satellite with 4 transponders each with a throughput of 250 MBPS.

In Ku-Band evidently no uniform trend for transponder design has emerged so far.

At present, FCC has assigned Ku-Band slots at 3° separations. From preliminary studies, it appears that 2° separation is feasible at an acceptable level of deterioration in performance. So far only 9 orbit slots at 3° separation have been allocated, remaining 17 slots are still available. For 2° separation 26 slots will be available.

1.4.2.1 Capacity Calculation

Case I: (a) 3° orbital separation, QPSK modulation. Usable orbital arc from 58°W to 143°W, with 13° deadband from 106°W to 119° for Telesat.

Number of available slots = 26

Assume: 9 Satellites @ 10 transponders of 48 MHz (80 MBPS)

9 Satellites @ 8 transponders of 54 MHz (90 MBPS)

8 Satellites @ 6 transponders of 72 MHz (120 MBPS)

Total throughput (single polarization)

$$= 9 \times 10 \times 80 + 9 \times 8 \times 90 + 8 \times 6 \times 120 = 19{,}440 \text{ MBPS}$$

Total throughput (double polarization) = 2 x 19,444 = 38,880 MBPS

(b) Same Case I (a) with 80, PSK

Total throughput (single polarization) = 29,160 MBPS

Total throughput (dual polarization) = 58,320 MBPS

Case II: (a) 2° orbital separation, QPSK modulation. Useable orbital arc from 58°W to 138°W, with 13° deadband from 106°W to 119° for Telesat.

Number of available slots = 35

Assume: 12 Satellites @ 10 transponders of 48 MHz (80 MBPS)

12 Satellites @ 8 transponders of 54 MHz (90 MBPS)

11 Satellites @ 6 transponders of 72 MHz (120 MBPS)

Total throughput (single polarization) - see Table 1-2.

= 12 x 10 x 80 + 12 x 48 x 90 + 11 x 6 x 120

= 26,160 MBPS

Total throughput (double polarization)

= 2 x 26,160

= 38,880 MBPS

(b) Using 8Ø, PSK modulate and same as a

Total throughput (single polarization) = 39,240 MBPS

Total throughput (dual polarization) = 78,480 MBPS

1.4.3 <u>Ka-Band Throughput Capacity</u>

Ka-Band satellites are inherently multibeam satellites. A total 2500 MHz bandwidth is available in this frequency band. Ka-Band satellites are still in the early developmental stages and are expected to be deployed in the late 1990s. A unified transponder layout has not emerged so far. However, it appears that the likely design will be a 20-beam satellite operating at a burst rate of 500 MBPS. A throughput of 10 GBPS or more is possible (see Table 1-2).

APPENDIX H
SATELLITE SYSTEM MARKET DEVELOPMENT

H.1 INTRODUCTION

The purpose of this subtask was to compare required, potential and actual capacities so that estimates of when Ka-band will be needed could be made. Required capacity refers to the capacity expected to be needed (as specified in Appendix G); Potential Capacity refers to the capacity expected to be possible; and actual capacity refers to the capacity expected to be available. The major steps conducted to accomplish this purpose were:

a. Specify factors influencing potential capacity.
b. Develop high, expected and low estimate of potential capacity.
c. Specify factors influencing actual capacity.
d. Develop high, expected and low estimates of actual capacity.
e. Compare required, potential and actual capacities.
f. Specify areas of uncertainty.

H.2 FACTORS INFLUENCING POTENTIAL CAPACITY

Three factors were considered when determining potential capacity:

a. Spacing (C- and Ku-bands) - see Appendix G for detailed discussion of spacing for C- and Ku-bands.
b. Frequency reuse (Ku-band) - See Appendix G.
c. Fill percentage (C- and Ku-transponders) - for potential capacity, this is the average percentage of satellite capacity that must be sold or leased before it is put into use.

The impact of each of these factors on potential capacity is specified in Table H-1.

H.3 DEVELOP ESTIMATES OF POTENTIAL CAPACITY

High, expected and low estimates of potential capacity were developed by projecting spacing, frequency, reuse, and fill percentage changes. These

projections were based on the report presented at the end of Appendix G and on interviews with providers and representatives of Government agencies. In Table H-2 are three scenarios that correspond to the high, expected and low estimates of potential capacity and that reflect factor forecasts or changes in spacing, reuse and fill percentage over time. Also present in Table H-2 are the high, expected and low forecasts of potential capacity. These forecasts also are graphed in Figure H-1.

H.4 SPECIFY FACTORS INFLUENCING ACTUAL CAPACITY

Only two factors were considered when determining actual capacity:

a. Fill percentage - for actual capacity, this is the average percentage of satellite capacity actually being used.
b. Growth beyond scheduled satellites.

For growth beyond scheduled satellites, actual capacity was expected to approach potential capacity by 2000 because of market demand (i.e., required capacity). As with estimates of potential capacity, .9, .8 and .7 were the fill percentages used to develop high, expected and low estimates of actual capacity.

H.5 DEVELOP ESTIMATES OF ACTUAL CAPACITY

High, expected and low estimates of actual capacity for C- and Ku-bands were developed on the basis of available information on current satellites in operation, plans for future satellites and fill percentages, as discussed above (See Appendix G). Forecasts considering growth rates are presented in Table H-3. The high, expected and low estimates also are graphed in Figure H-2.

H.6 COMPARE REQUIRED, POTENTIAL AND ACTUAL CAPACITIES

The factors which vary and those which are constant across high, expected and low estimates of required, potential and actual capacity are outlined in Table H-4. The high, expected and low estimates for required, potential and actual capacities are listed, by year, in Table H-5. These capacities are graphed in Figure H-3. Figure H-3 can be used to determine the saturation date of C- and

Ku-bands, given various assumptions. For example the following assumptions can be made and their impact noted as in Figure H-4.

a. Assuming expected required and expected potential capacities with actual equalling potential, Ka-band will be needed around 1990.

b. Assuming low required and high potential capacities with actual equalling potential, Ka-band will be needed around 1995.

H.7 AREAS OF UNCERTAINTY

The following are the major areas of uncertainty where sensitivity analyses need to be conducted to determine the impact on the forecasts of varying the various factors.

H.7.1 Economic Factors

a. National - International economic conditions (reflected in impacted baseline forecasts)

b. Relative costs of satellite and terrestrial systems (reflected in net addressable forecasts)

c. Provider requirements - Satellite/terrestrial differential, fill percentage (reflected in potential and actual capacity forecasts).

H.7.2 Technological Factors

a. Modulation and coding improvements: #HVC/36 HMz, #MBPS/36 MHz, #KBPS/HVC (reflected in required capacity forecasts)

b. Spacing and frequency reuse (reflected in potential capacity forecasts)

c. Creative integration of technological improvements (reflected in impacted baseline forecasts).

TABLE H-1. COMPOSITE IMPACTS OF SELECTED FACTORS ON POTENTIAL CAPACITIES OF C AND Ku BANDS

BAND	SPACING #o	REUSE Y/N	36 MHz #	FILL PERCENT .9	.8	.7
C	4	Y	432	389	346	302
	3	Y	552	497	442	386
	2	Y	744	670	595	521
Ku	3	N	324	292	259	227
	2	N	436	392	349	305
	3	Y	648	583	518	454
	2	Y	872	785	698	610

TABLE H-2. DEVELOPMENT OF ESTIMATES OF POTENTIAL CAPACITY

Factor Forecasts

		High			Expected			Low		
		1980	1990	2000	1980	1990	2000	1980	1990	2000
Spacing	C	4	3	2	4	3	3	4	4	3
	Ku	3	2	2	3	3	2	3	3	3
Reuse	C	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Ku	N	Y	Y	N	Y	Y	N	Y	Y
Fill Percent		.9	.9	.9	.8	.8	.8	.7	.7	.7

Capacity Forecasts	1980	1990	2000
(36 MHz Transponders)			
High	681	1282	1455
Expected	605	960	1140
Low	529	756	840

TABLE H-3. ESTIMATED ACTUAL CAPACITIES FOR C AND KU BANDS FOR 1980, 1990 and 2000

Forecasts Considering Growth Rates

Band	1980	1990	2000
C	156	528	744
Ku	0	495	872
Total	156	1023	1616

Forecasts Considering Fill Percentage

	1980	1990	2000
High Estimate (Fill % = 90)	140	921	1455
Expected (Fill % = 80)	125	818	1293
Low Estimate (Fill % = 70)	109	716	1131

TABLE H-4. SUMMARY OF FACTORS, VARIED AND HELD CONSTANT, IN DEVELOPING HIGH, EXPECTED AND LOW ESTIMATES OF REQUIRED, POTENTIAL AND ACTUAL CAPACITY

FACTORS	CAPACITIES		
	Required	Potential	Actual
Factors that varied	1. Percent removed - common carrier consideration 2. Analog modulation techniques #HVC/Trans	1. Spacing 2. Fill Factor	1. Fill Factor
Factors Held Constant	1. Analog coding techniques #KBPS/HVC 2. Digital Modulation techniques, #MBPS/Trans 3. Percent voice on analog and digital	1. Reuse	1. Growth beyond schedules

TABLE H-5. SUMMARY OF REQUIRED, POTENTIAL AND ACTUAL CAPACITIES

	1980			1990			2000		
	High	Expected	Low	High	Expected	Low	High	Expected	Low
Required	263	263	263	1236	1045	922	2960	2468	2073
Potential	681	605	529	1282	960	756	1455	1140	840
Actual	140	125	109	921	818	716	1455	1293	1131

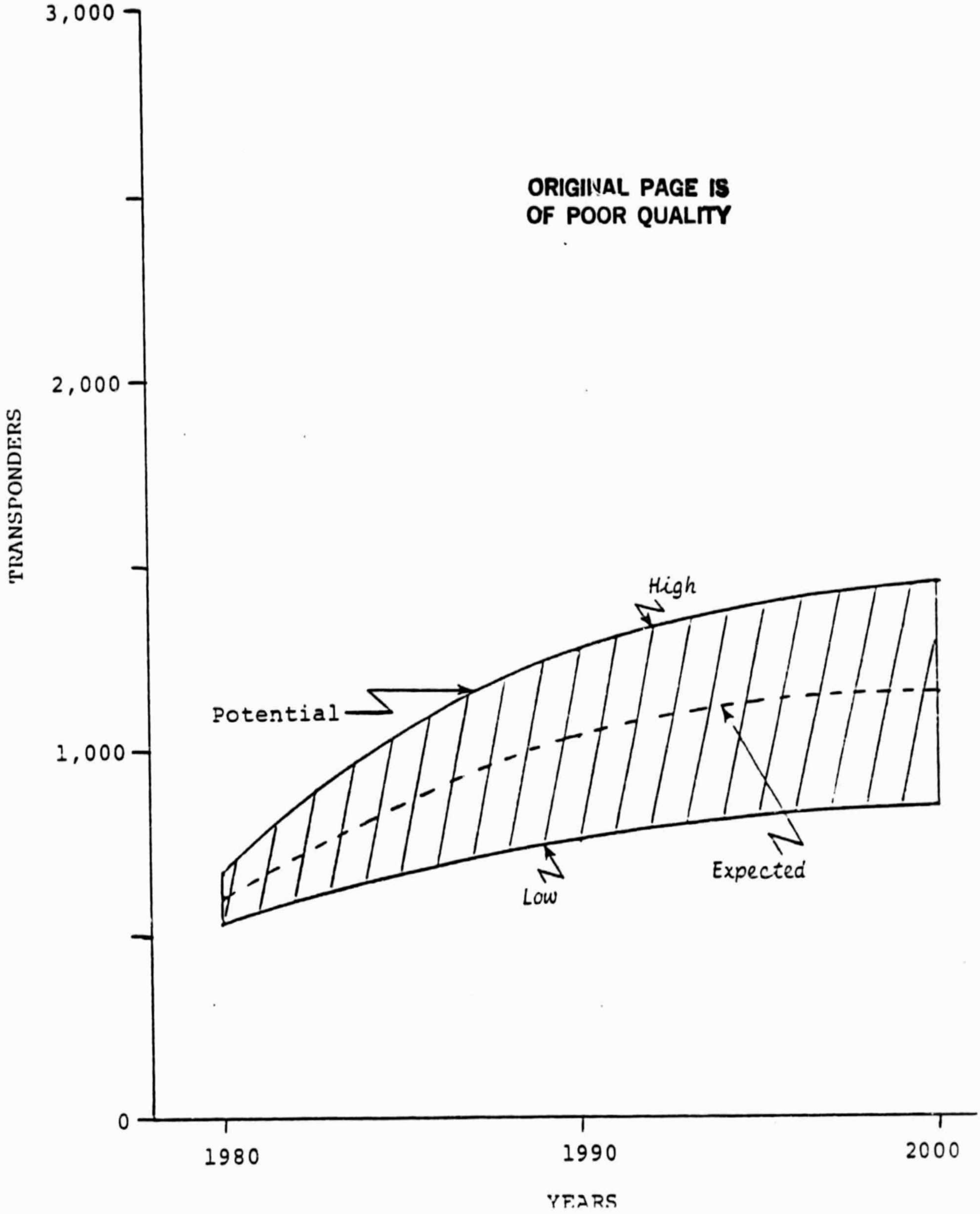

FIGURE H-1. HIGH, EXPECTED AND LOW ESTIMATES OF POTENTIAL C-PLUS KU-BAND CAPACITY 9-001

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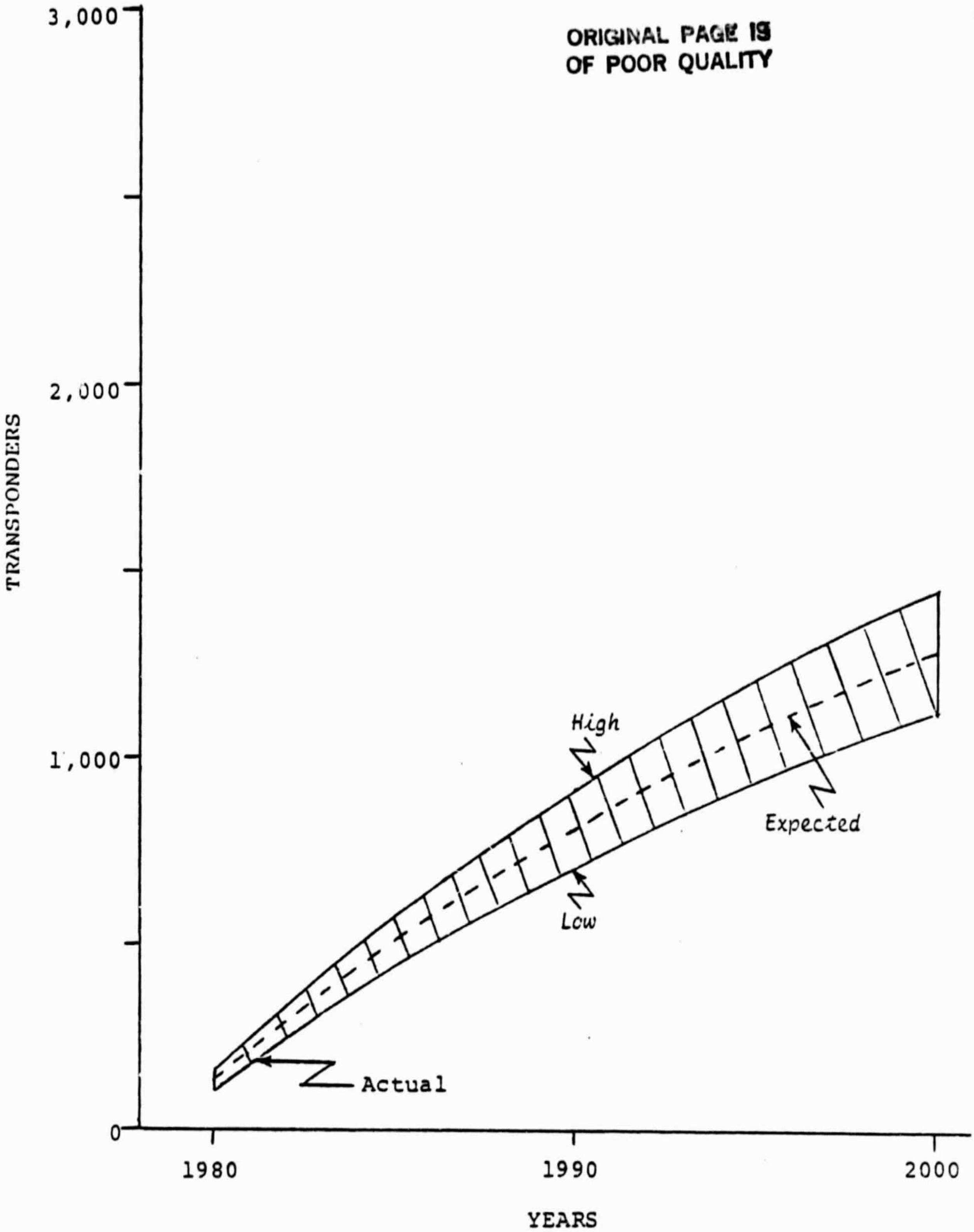

FIGURE H-2. HIGH, EXPECTED AND LOW ESTIMATES OF ACTUAL C-PLUS KU-BAND CAPACITY

9-001

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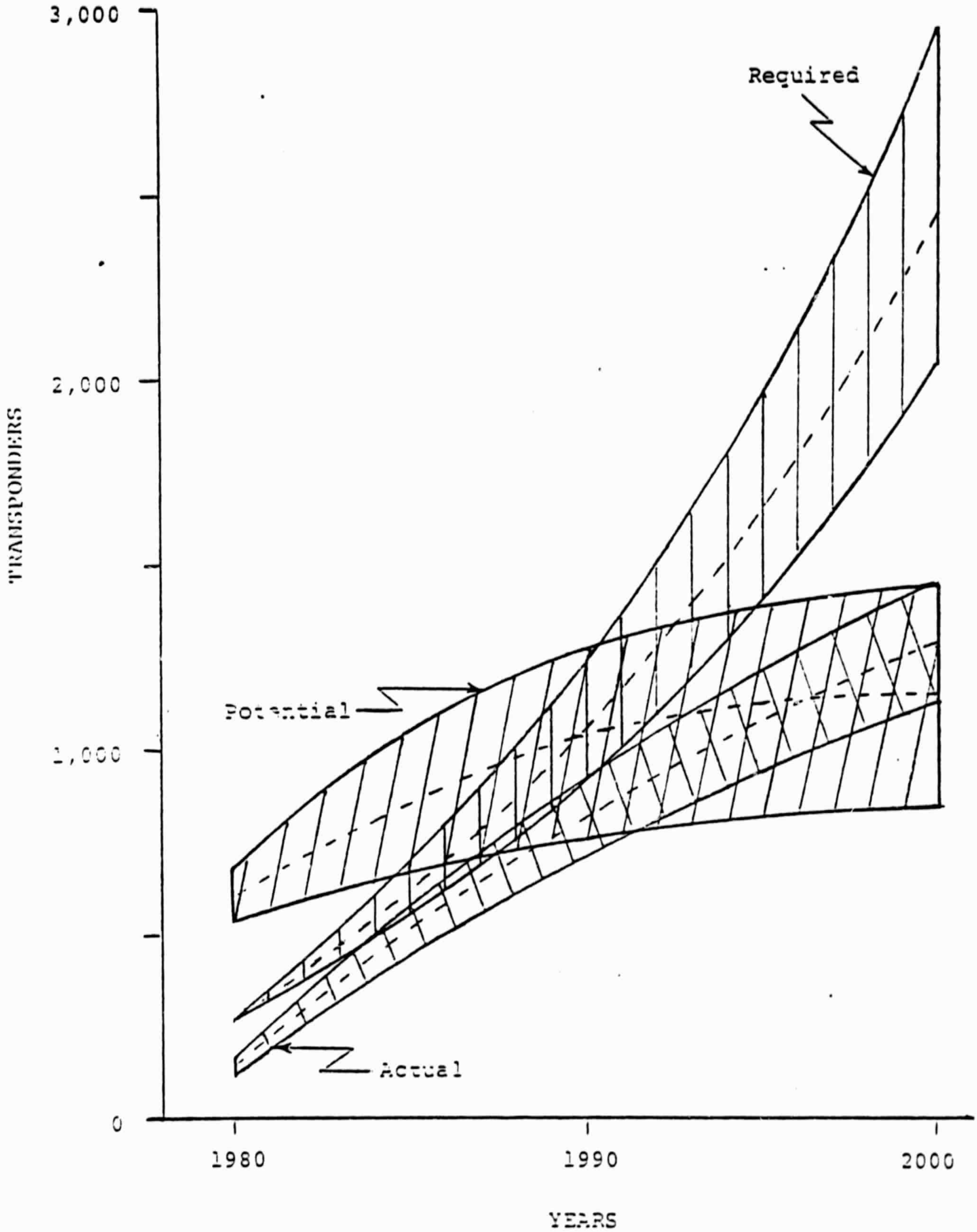


FIGURE H-3. COMPARISON OF ESTIMATES OF CAPACITIES

9-00?

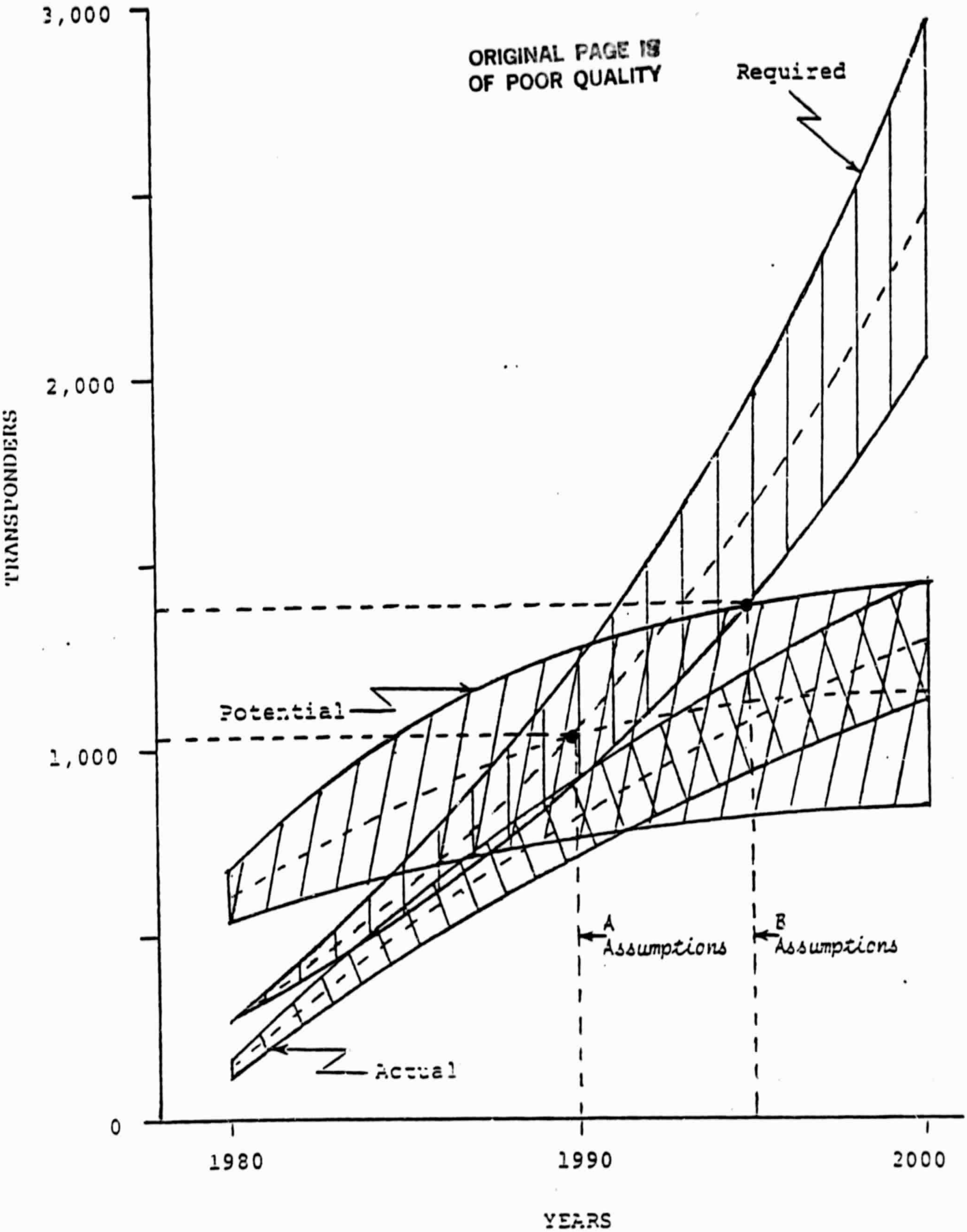


FIGURE H-4. TWO SCENARIOS FOR SATURATION OF C AND KU-BANDS

APPENDIX I
30/20 GHZ NET ACCESSIBLE MARKET

I.1 INTRODUCTION

This task is to determine from the addressable Ka band traffic forecast (the portion of the total satellite market which is capable of being served by 30/20 GHz systems) the maximum amount of traffic, or accessible traffic (that portion of the net addressable likely to be implemented on a Ka-band system), which could be served by such a system. Two approaches to implementation are considered: An established carrier network and a specialized carrier network. The established carrier network consists of those carriers with extensive terrestrial facilities, microwave and cable, such as Western Union. The specialized carrier network consists of those carriers with long distance facilities but little capability to hub local cities together, such as MCI.

I.1.1 Type of Traffic

Four kinds of traffic were considered in the network crossover distance model. Figure I-1 shows the alternative combinations of traffic. The four traffic alternatives are known as satellite inter-station traffic, intra-cellular traffic, terrestrial inter-SMSA traffic and satellite inter-SMSA traffic. In the example, it is assumed that the distance between the two earth stations A and A^1 is greater than the minimum crossover mileage. The circles surrounding the earth station locations represent the maximum SMSA hubbing distance. The satellite inter-station traffic between A and A^1 is included in the network market values.

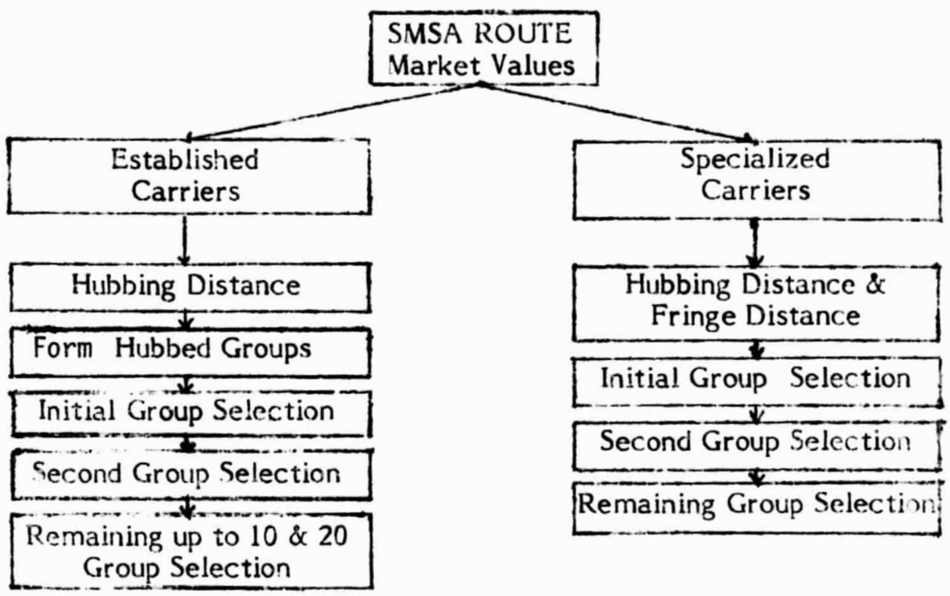
The SMSA marked as "B" is subordinated to the earth station "A" because it falls within the hubbing distance and its traffic called intra-cellular, is carried terrestrially. Thus this traffic was removed as part of the procedures to determining the Ka band satellite addressable traffic. A third type of traffic is between two subordinated SMSAs within different earth station cells. Traffic between "B" and "C" is considered to be terrestrial inter-SMSA or the distance between these points is less than the mileage crossover advantage of satellite vs. terrestrial, as determined by the crossover analysis performed. Thus this traffic,

also, was removed as part of the procedures to determining the Ka band satellite addressable traffic.

Traffic between two subordinated SMSAs such as "B" to "D" which are greater than the hubbing distance is called satellite inter-SMSA and its value is included in the network market value.

I.1.2 Network Optimization Model

The network market optimization model is a technique of attaining the maximum market value for "N" number of earth station locations. It does this by consecutively selecting the optimum earth station location.



a. SMSA Route Market Value. The relative market value is determined for each SMSA through the use of the market distribution model (MDM, see Appendix C) for all routes having satellite traffic. The following files and weights were used with the MDM.

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File	Weight
Population in 1980	30
1980 Business Telephones	35
Bank Deposits	10
Non-Farm Employment	15
Number of Computer Sites	10

b. Hubbing Distance. The hubbing distance was determined from the crossover analysis (see Appendix E). This is the same distance obtained from the terrestrial/satellite crossover (170 miles) used to determine satellite addressable traffic. This is only true for the established carriers, however, with an extensive terrestrial network. For specialized carriers which must lease lines from the established carriers the hubbing distance is 85 miles.

c. Form Hubbed Groups. Once the hubbing distances and the market value of each route were determined it was necessary to form all possible hubbed groups. This was done by using each SMSA as a center and then hubbing all SMSAs within the hubbing distance. Thus 313 groups were formed with 97,969 routes.

d. Initial Group Selection. Once all the groups are formed it was necessary to determine the group with the highest market value. This was done by summing all the route market values for the different groups. Once this was done it was only necessary to select the group with the highest market value. Where this group overlapped other groups the particular SMSAs and routes associated with the chosen groups were removed from the remaining groups.

e. Second Group Selection. Following the initial group selection it is necessary to consider only those route market values to those SMSAs chosen. This done for every remaining group, the group with the highest market value in respect to the initially selected group is then chosen as the second group.

f. Remaining Groups Selection. The process for selecting the remaining groups is very similar to the selection of the second group. Every time a group is chosen those SMSAs and routes

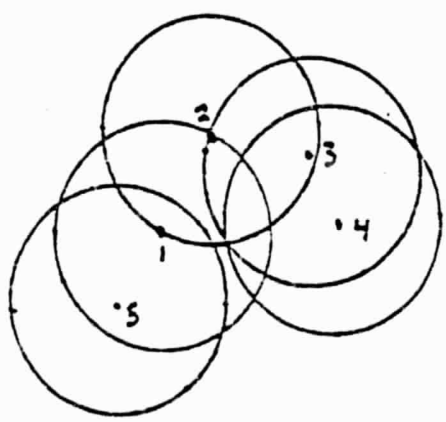
which overlap with remaining groups are removed from the remaining groups. The market route values of SMSAs not chosen are computed and the highest group market value is selected. This assures that the group adding the most to the network already in place will always be selected.

g. Established Carriers Model. The network optimization model was used to select the top ten and twenty sites across the United States.

h. Specialized Carrier Model. The network optimization model ranked all groups in order. Besides making the assumption that specialized carriers would put earth stations wherever feasible, the concept of fringe SMSAs was introduced. Fringe SMSAs are those SMSAs which are too far (over 60 miles) to be routed directly back to the central earth station if only a small amount of traffic exists. It was, however, possible to route this traffic through larger SMSAs if they were within 25 miles.

Example of Network Optimization Model using 5 Nodes

Nodes with hubbing circles shown



Route values as obtained by MDM.

ROUTE	VALUE
1-2	1.2
1-3	.3
1-4	.8
1-5	.1
2-3	.4
2-4	.3
2-5	.2
3-4	.7
3-5	.3
4-5	.2

Group formation

GROUP	HUBBED
1	2,5
2	1,3
3	2,4
4	3
5	1

Sum of all route market values and group market values.

SMSA	SUM OF ALL ROUTE MARKET VALUES
1	2.4
2	2.1
3	1.7
4	2.0
5	.8

GROUP	HUBBED	GROUP MARKET VALUE
1	2,5	5.3
2	1,3	6.2
3	2,4	5.8
4	3	3.7
5	1	3.2

a. Initial Group Selection. Select the largest group market value = group number 2

b. Second Group Selection. Remove SMSAs and route values found in the initial group from all other groups.

GROUP	HUBBED	GROUP VALUE	ROUTE MARKET VALUE OF REMAINING GROUPS TO GROUPS SELECTED
~~1~~	~~2,5~~	~~5.3~~	
~~2~~	~~1,3~~	~~6.2~~	
~~3~~	~~2,4~~	~~5.8~~	
4	~~3~~	~~3.7~~ 2.0	1.8
5	~~1~~	~~3.2~~ .8	.6

Select the group with the largest composite route value to all groups previously selected.

Group Number 4 would be selected.

c. Remaining Group Selection. Remove SMSAs and route market values found in the group selected from all other groups. Determine the route market values of the remaining groups to the groups previously selected. Repeat until all SMSAs are used up in the specialized carrier model or until the largest 20 groups have been selected in the common carrier model.

I.2 ESTABLISHED CARRIER NETWORK REPORTS

a. Summary Network Optimization Report. The first report (Table I-1) summarizes the top 10 and 20 earth station sites (groups) around the United States. The first column shows the order in which the sites were chosen. The second column shows the SMSA where the earth station is to be located. This is the central SMSA of the group. The next column shows the number

of SMSAs in that particular group. The fourth column shows the group market value which is added by that particular group to the existing network (those groups previously selected). This value which is generally descending, is always the highest given the previous network. Adding a group may mean the value of adding a successive group is higher. This is the case with adding group 5 and then group 6. The cumulative group market value shown in the last column shows the percentage of the total satellite market captured up to that particular group. For instance, groups 1-10 capture 42.5 percent of the total market.

b. Summary 10 and 20 Earth Station Network Reports. The next two reports (Tables I-2 and I-3) summarize the amount of traffic each group contributes to the network. The information in the first three columns is the same as with the summary network optimization report. The fourth column, group market value, is recomputed based on the network having either 10 or 20 earth stations. The last column, cumulative group market value follows from this.

c. Network Optimization Report. This report (Table I-4) shows the top 10 and 20 earth station sites in the United States in detail. The first column of the initial line of each group shows the order in which the sites were chosen. Next on that line is the central SMSA where the earth station for that group is located. Next is the group market value which is that percentage of the satellite market added by adding that particular group to the existing network. The cumulative group market value is the percentage of the total satellite market captured up to that particular group. The next line of every group shows the number of subordinate SMSAs (includes central SMSA) which are in the group and the distance from the central SMSA they are located. Also shown are the individual market values which is the addition to the existing network that that particular SMSA contributes.

d. Ten and 20 Earth Station Network Reports. These reports (Tables I-5 and I-6) are very similar to the network optimization

report only the market values are recomputed considering the actual number of earth stations in the network.

e. Ten and 20 Earth Station Network Maps. The locations and the hubbing distance of these two networks are shown on maps of the United States (Figures I-2 and I-3).

I.3 SPECIALIZED CARRIER NETWORK REPORTS

a. Summary Network Optimization Report. This report (Table I-7) summarizes the selection of all 313 SMSAs across the United States. The first column shows the order in which the sites were chosen. The second column shows the SMSA where the earth station is to be located. The next column shows the number of SMSAs in that particular group. The group market value is the percentage of the satellite market added by adding that particular group to the network. The cumulative group market value is the percentage of the total satellite market captured up to that particular group. These last two columns are zero for the initial group selected since these values depend on the network previously established.

b. Network Optimization Report. This report (Table I-8) shows the details of the selection of all 313 SMSAs across the country. The initial line of each group shows the order in which the sites were chosen. Next on that line is the central SMSA where the earth station for that group is located. Next is the group market value which is that percentage of the satellite market added by adding that particular group. The cumulative group market value is the percentage of the total satellite market captured up to that particular group. The next line of every group shows the number of subordinate SMSAs (includes central SMSA) which are in the group and the distance from the central SMSA they are located. Also shown are the individual market values which is the addition to the existing network that that particular SMSA contributes.

c. Minimum Network Report. The minimum network size (see Table I-8) is defined as the smallest viable network based on

geographical market coverage. From other common carrier experience it has become clear that a network serving only a few markets and offering limited market coverage could not remain viable. In the early years of the specialized microwave carriers, for example, it took time for them to expand their network coverage to sufficient geographical coverage to attract new customers. Large communications users have a need to communicate to most of the principal U.S. cities and normally will seek a competitively priced carrier which offers service to these largest 15-20 metropolitan areas.

From marketing experience, it was determined that the minimum required market coverage is 30 percent of the total accessible market. At a 30 percent coverage level almost all of the principal centers of business activity will be served. Accordingly, an analysis was conducted to determine the total number of SMSA market values necessary to generate a 30 percent market coverage. Using Table I-8 and finding where the cumulative market value is at least 30 percent gives a network of the top 22 SMSAs.

d. Minimum Network Map. The locations for the earth stations of the minimum network are shown on a map of the United States (Figure I-4).

e. Maximum Network Report. The maximum network report (same as Table I-8) employed a market analysis methodology which involved creation of an earth station site cost model to determine the smallest amount of traffic in an SMSA location to economically justify placement of a specialized carrier earth station. The smallest market values are developed below.

1. <u>Number of Circuits Required to Install a Ka-band Earth Station</u>

   Annual Revenue Required for Ka-band Earth Station = \$1.73 million

   Annual Space Segement Cost for VF Circuit = \$1.63 K

   Minimum number of voice channels required to justify Ka-band Earth Station is calculated as follows:

$$n = \frac{\$173M + n \times \$1.63 \times 10^3 M}{\text{VF Yearly Tariff}}$$

n (VF yearly tariff - 1.63×10^{-3}m) = \$1.73 M

$n (8940 - 1630) = 1.73 \times 10^{-6}$

$n = 236.7 = 237$ VF Circuits

Minimum traffic required on an Earth Station to be cost justified is 15.2 Mbps.

Since the minimum earth station was designed for constant use, a usage curve must be assumed and a peaking factor used to relate the traffic needed to justify an earth station with the peak hour traffic in the system.

Peaking Factor = 3

Minimum Peak Hour Traffic to Justify E/S = 45.6 Mbps

2. Ka-band Traffic Assumptions

a) Both C- and Ku-bands will fill up before Ka-band is used; only 2 Ka-band crossovers are less than crossovers for C or Ku-bands.

b) All traffic beyond crossover distance will be satellite traffic; no margin is added to reflect needed incentive to switch to satellite.

c) Demand for satellite traffic will be a "minimum" demand forecast.

d) C- and Ku-band capacity will be a "maximum" capacity forecast.

3. Ka-band Traffic Calculations

	1990	2000
Max C & Ku Capacity		
Transponders	1282	1455
MBPS	115380	130950
Min Satellite Demand		
Transponders	922	2073.2
MBPS	82980	186588

Needed Capacity (Capacity - Demand)

Transponders	+360*	-618**
MBPS	+32400*	-55620

* Excess Capacity

** Needed Capacity = Ka Band Traffic

Ka Band Net Addressable Forecast

Transponders	942	1899
MBPS	84780	170910

4. Comparison: Ka Net Addressable and Difference Between C & Ku Capacity and Demand

	1990		2000	
	Ka-Net	Need	Ka-Net	Need
Transponders	942	0	1899	618
MBPS	84780	0	170910	55620

Minimum Group Market Value to Justify

Earth Station $\frac{45.6}{55,620}$ = .082%

Using the network optimization report and the minimum group market value to justify an earth station (.082 percent) it was found that 100 percent of the market or all 313 SMSAs could be covered with 110 earth stations.

e. Most Efficient Network Optimization Report. The earth station network which represents the most efficient size is the number of stations where each one incrementally generates sufficient traffic to economically justify it within a competitive carrier environment. An important element in this analysis was to attempt to define the extent of the competition in the 1990-2000 time period for 30/20 GHz markets.

A competitive market scenario was created in which as many as four specialized carriers will be operating 30/20 GHz satellite networks. It is foreseen that the need for greater capacity and the availability of this higher frequency spectrum may attract four major specialized carrier competitors.

A further effort is to define the relative market shares of each of these competitors for 30/20 GHz traffic. In the absence of any perceived obvious advantage one carrier may have over

the others, it was decided that their respective market shares would be divided equally in fourths or 25 percent of the accessible market traffic in all locations served.

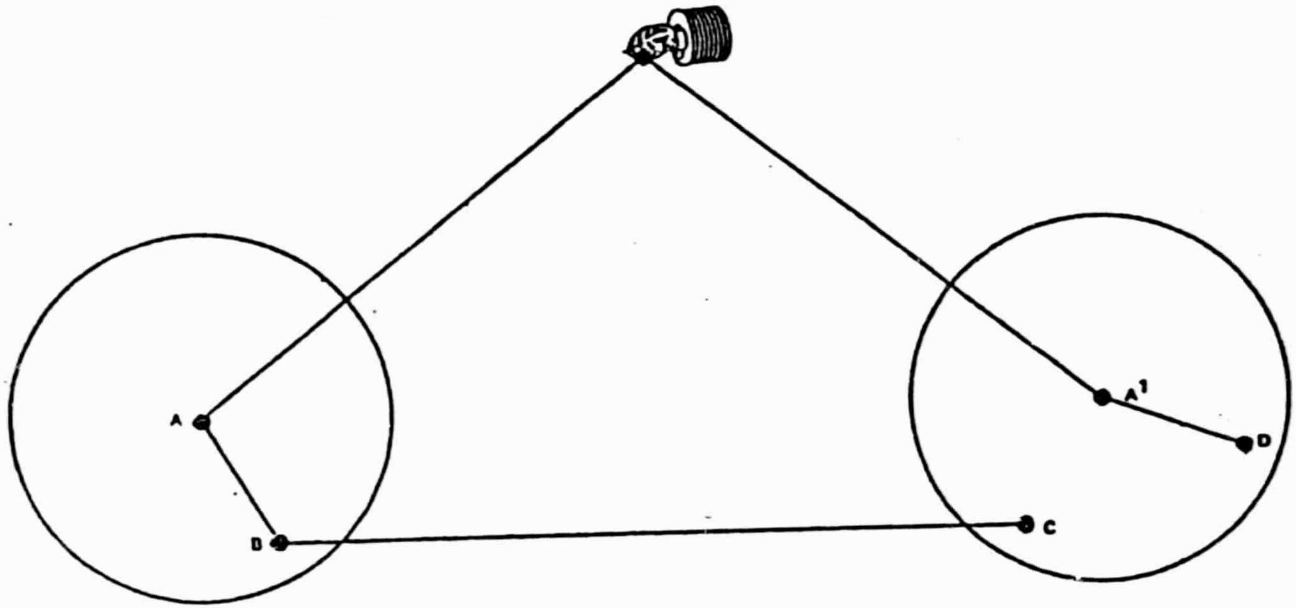
Thus, given a market environment, where, due to competition, only 25 percent of the accessible market was available to one specialized carrier network, a minimum traffic requirement level could be established for the smallest SMSA.

Minimum Group Market Value to Justify an Earth Station	.082 percent
Market Captured by Largest Competitor in Smallest Markets	25 percent
Most Efficient Group Market Value to Justify an Earth Station	.328 percent

Using the network optimization report (Table I-8) and the most efficient group market value to justify an earth station (.328 percent) it was found that 98.27 percent of the market or 307 SMSAs could be covered with 104 earth stations.

f. Most Efficient Network. This is the same as the network optimization report (Table I-8) except the group market value and the cumulative group market value have been recomputed considering the actual network consisting of the first 74 groups (or earth station sites). This is given in Tables I- 9 and I-10.

g. Most Efficient Network Map. The locations of the earth stations for the most efficient network is shown on a map of the United States (Figure I-5).



TRAFFIC LEGEND

A–A¹: SATELLITE INTER-STATION

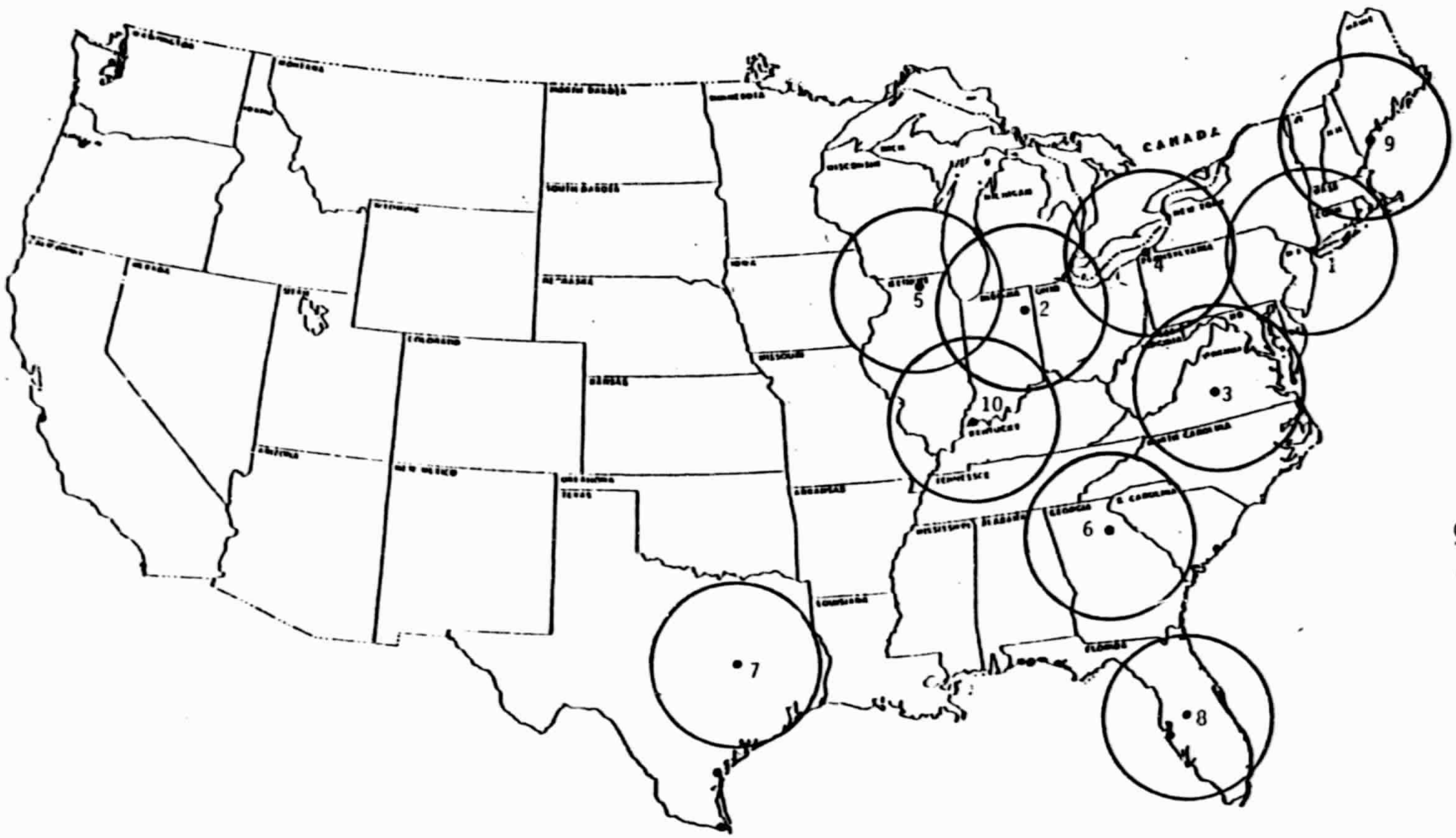
B–A: INTRA-CELLULAR

B–C: TERRESTRIAL INTER-SMSA

B–D: SATELLITE INTER-SMSA

FIGURE I-1. TRAFFIC DISTANCE CRITERIA

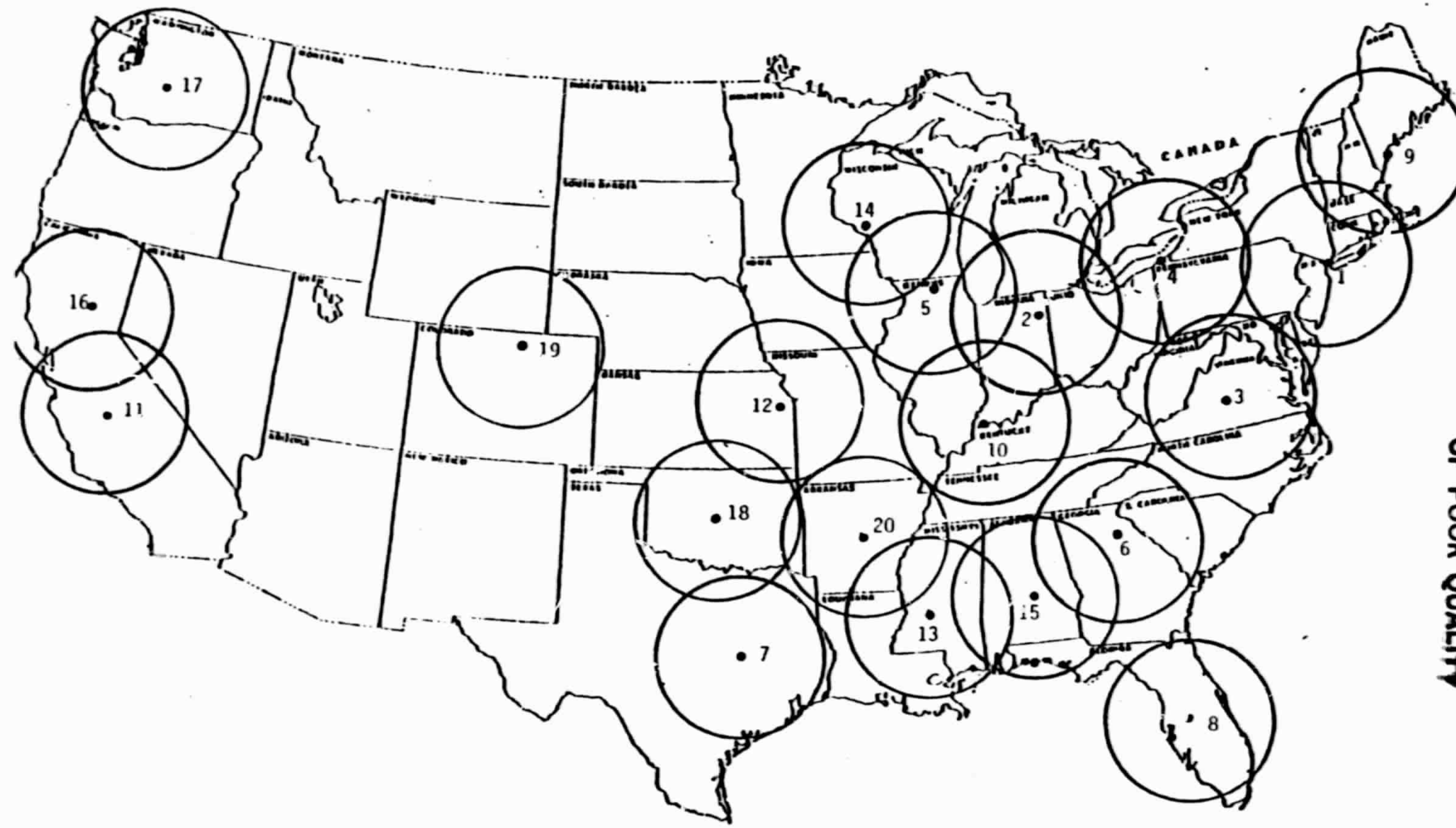
ESTABLISHED COMMON CARRIER - 10 EARTH STATION MODEL



PERCENT CAPTURED = 42.53

FIGURE I-2. ESTABLISHED COMMON CARRIER - 10 EARTH STATION MODEL

ESTABLISHED COMMON CARRIER - 20 EARTH STATION MODEL



PERCENT CAPTURED = 74.98

FIGURE I-3. ESTABLISHED COMMON CARRIER - 20 EARTH STATION MODEL

SPECIALIZED COMMON CARRIER - MINIMUM NETWORK

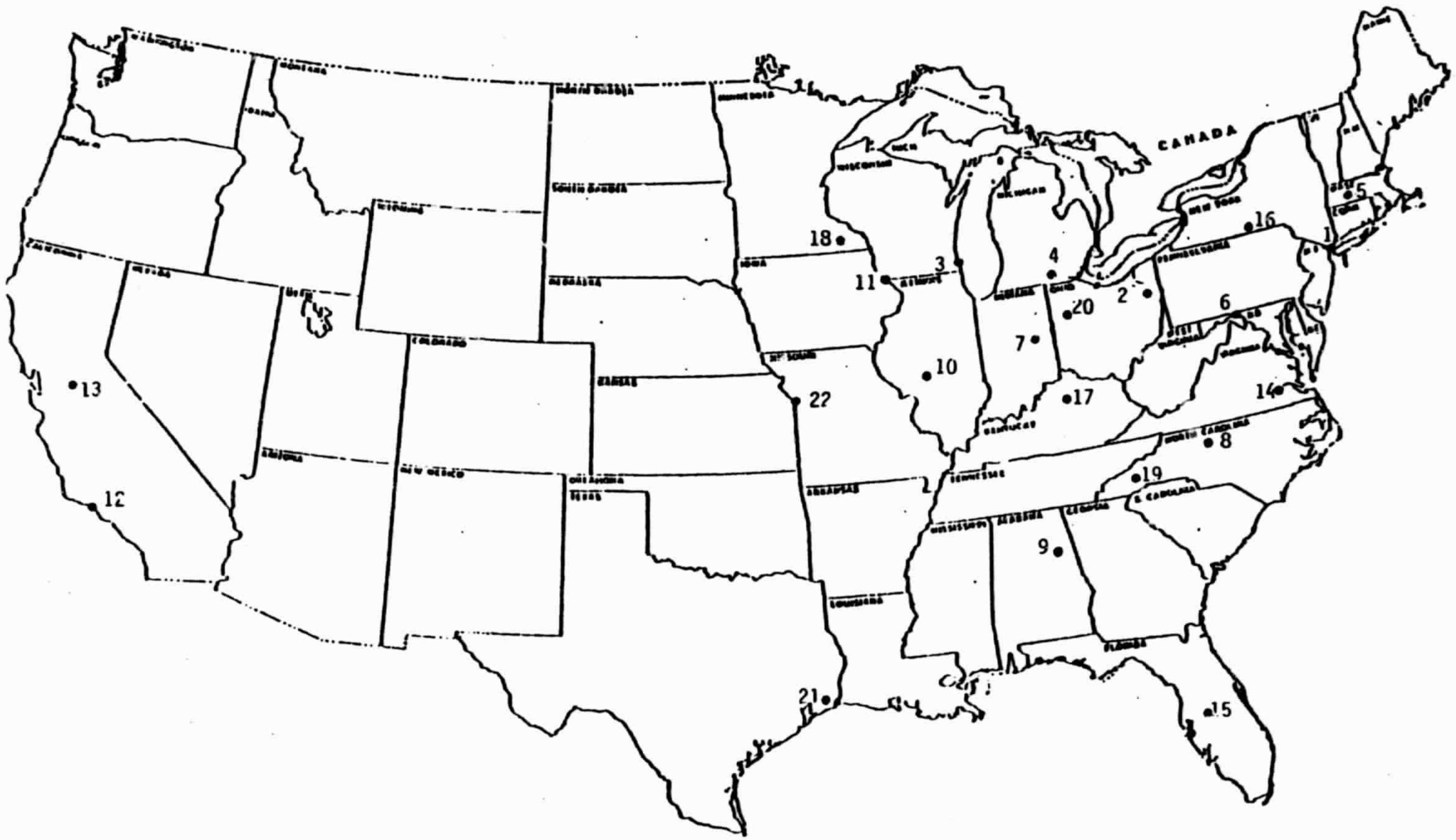


FIGURE I-4. SPECIALIZED COMMON CARRIER - MINIMUM NETWORK

SPECIALIZED COMMON CARRIER - MOST EFFICIENT NETWORK

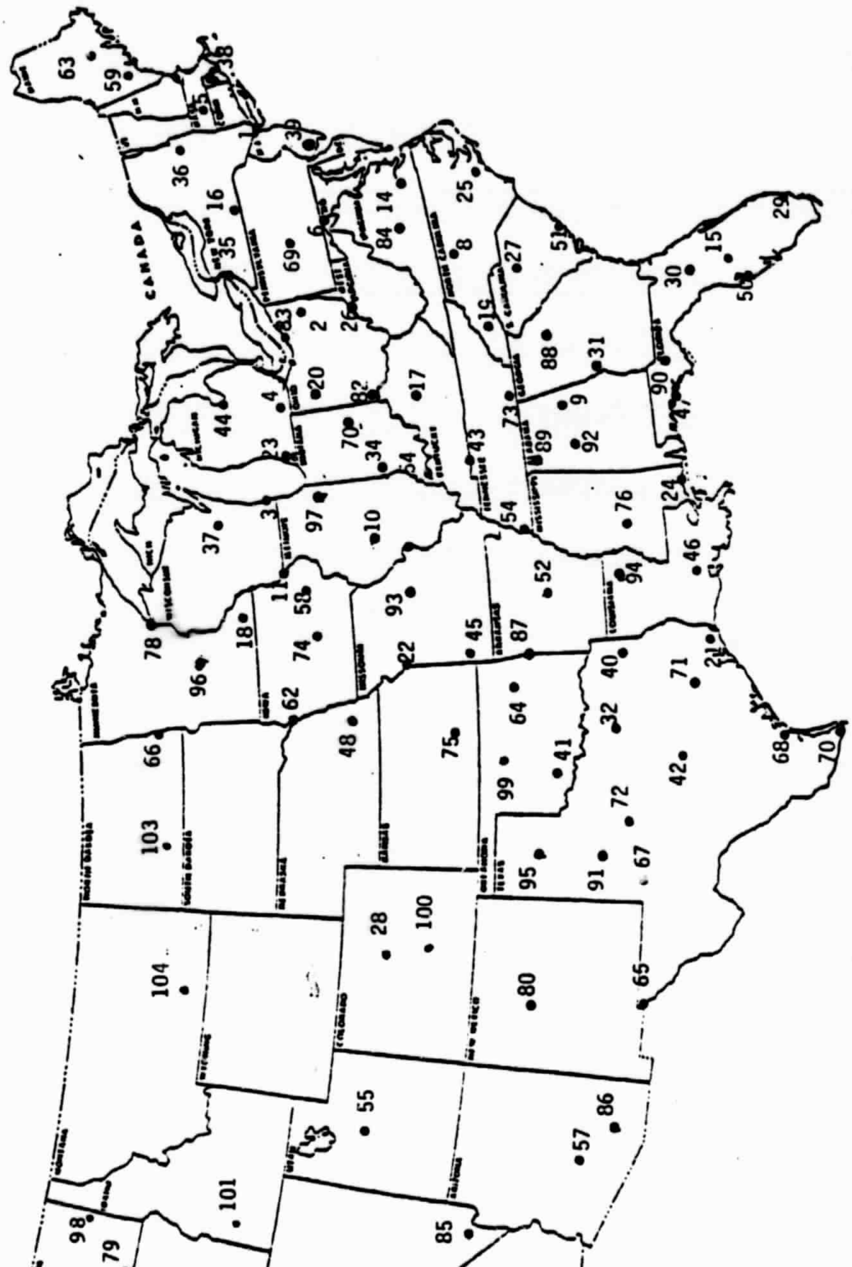


FIGURE I-5. SPECIALIZED COMMON CARRIER - MOST EFFICIENT NETWORK

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TABLE I-1. SUMMARY NETWORK OPTIMIZATION REPORT

		NO. SMSA'S	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
1	NEW YORK NY-NJ	42		
2	FORT WAYNE IN	33	5.69	5.69
3	LYNCHBURG VA	19	5.20	10.89
4	ERIE PA	15	5.33	16.23
5	ROCKFORD IL	20	4.71	20.94
6	ATHENS GE	15	5.16	26.10
7	BRYAN-COLLEGE STATION TX	12	3.89	29.99
8	LAKELAND-WINTER HAVEN FL	13	4.10	34.10
9	PORTLAND ME	12	4.22	38.31
10	EVANSVILLE IN-KY	7	4.22	42.53
11	VISALIA-TULARE-PORTERVILLE CA	11	4.10	46.64
12	LAWRENCE KS	10	4.27	50.90
13	JACKSON MS	10	4.10	55.01
14	EAU CLAIRE WI	6	3.40	58.41
15	MONTGOMERY AL	6	2.75	61.16
16	CHICO CA	8	2.74	63.89
17	YAKIMA WA	9	2.86	66.75
18	OKLAHOMA CITY OK	6	2.77	69.52
19	FORT COLLINS CO	6	2.72	72.24
20	LITTLE ROCK-NORTH LITTLE ROCK AR	5	2.75	74.98

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TABLE I-2. SUMMARY 10 EARTH STATION NETWORK REPORT

		NO. SMSA'S	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
1	NEW YORK NY-NJ	42	10.02	10.02
2	FORT WAYNE IN	33	8.09	18.11
3	LYNCHBURG VA	19	4.69	22.80
4	ERIE PA	15	4.18	26.97
5	ROCKFORD IL	20	3.31	30.29
6	ATHENS GE	15	3.34	33.62
7	BRYAN-COLLEGE STATION TX	12	2.35	35.98
8	LAKELAND-WINTER HAVEN FL	13	2.25	38.23
9	PORTLAND ME	12	2.19	40.42
10	EVANSVILLE IN-KY	7	2.11	42.53

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TABLE I-3. SUMMARY 20 EARTH STATION NETWORK REPORT

		NO. SMSA'S	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
1	NEW YORK NY-NJ	42	13.13	13.13
2	FORT WAYNE IN	33	11.03	24.16
3	LYNCHBURG VA	19	5.82	29.98
4	ERIE PA	15	5.20	35.18
5	ROCKFORD IL	20	4.53	39.71
6	ATHENS GE	15	4.28	43.99
7	BRYAN-COLLEGE STATION TX	12	3.59	47.57
8	LAKELAND-WINTER HAVEN FL	13	2.98	50.56
9	PORTLAND ME	12	2.73	53.28
10	EVANSVILLE IN-KY	7	2.80	56.08
11	VISALIA-TULARE-PORTERVILLE CA	11	3.07	59.15
12	LAWRENCE KS	10	2.67	61.82
13	JACKSON MS	10	2.39	64.21
14	EAU CLAIRE WI	6	1.93	66.14
15	MONTGOMERY AL	6	1.50	67.64
16	CHICO CA	8	1.59	69.24
17	YAKIMA WA	9	1.53	70.77
18	OKLAHOMA CITY OK	6	1.45	72.22
19	FORT COLLINS CO	6	1.39	73.61
20	LITTLE ROCK-NORTH LITTLE ROCK AR	5	1.37	74.98

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TABLE I-4. ESTABLISHED CARRIER NETWORK OPTIMIZATION REPORT

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
1 NEW YORK NY-NJ				
1 ALBANY-SCHENECTADY-TROY NY	134			
2 ALLENTOWN-BETHLEHEM-EASTON PA-NJ	78			
3 ATLANTIC CITY NJ	99			
4 BALTIMORE MD	171			
5 BINGHAMTON NY-PA	138			
6 BRIDGEPORT CT	52			
7 BRISTOL CT	85			
8 DANBURY CT	54			
9 FALL RIVER MA-RI	162			
10 FITCHBURG-LEOMINSTER MA	171			
11 HARRISBURG PA	156			
12 HARTFORD CT	99			
13 JERSEY CITY NJ	3			
14 LANCASTER PA	131			
15 LONG BRANCH-ASBURY PARK NJ	31			
16 MERIDEN CT	83			
17 NASSAU-SUFFOLK NY	20			
18 NEW BEDFORD MA	171			
19 NEW BRITAIN CT	90			
20 NEW BRUNSWICK-PERTH AMBOY-SAYR N	30			
21 NEW HAVEN-WEST HAVEN CT	68			
22 NEW LONDON-NORWICH CT-RI	108			
23 NEW YORK NY-NJ	0			
24 NEWARK NJ	10			
25 NEWBRGH-MIDDLETOWN NY	55			
26 NORTHEAST PENNSYLVANIA PA	102			
27 NORWALK CT	39			
28 PATERSON-CLIFTON-PASSAIC NJ	16			
29 PHILADELPHIA PA-NJ	82			
30 PITTSFIELD MA	125			
31 POUGHKEEPSIE NY	68			
32 PROVIDENCE-WARWICK-PAWTUCKET RI-	154			
33 READING PA	106			
34 SPRINGFIELD-CHICOPEE-HOLYOKE CT-	120			
35 STAMFORD CT	33			
36 TRENTON NJ	54			
37 VINELAND-MILLVILLE-BRIDGETON NJ	103			
38 WATERBURY CT	75			
39 WILLIAMSPORT PA	162			
40 WILMINGTON DE-NJ	107			
41 WORCESTER MA	155			
42 YORK PA	154			
2 FORT WAYNE IN			5.69	5.69
43 ANDERSON IN	74	0.10		
44 ANN ARBOR MI	111	0.14		
45 BATTLE CREEK MI	86	0.11		

TABLE I-4. ESTABLISHED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	46 BENTON HARBOR MI	99	0.10		
	47 BLOOMINGTON IN	151	0.10		
	48 CHICAGO IL	142	0.83		
	49 CINCINNATI OH-KY	140	0.26		
	50 COLUMBUS OH	136	0.25		
	51 DAYTON OH	103	0.19		
	52 DETROIT MI	138	0.59		
	53 ELKHART IN	61	0.10		
	54 FLINT MI	153	0.15		
	55 FORT WAYNE IN	0	0.14		
	56 GARY-HAMMOND-EAST CHICAGO IN	121	0.12		
	57 GRAND RAPIDS MI	133	0.15		
	58 HAMILTON-MIDDLETOWN OH	119	0.12		
	59 INDIANAPOLIS IN	105	0.22		
	60 JACKSON MI	89	0.12		
	61 KALAMAZOO-PORTAGE MI	87	0.12		
	62 KANKAKEE IL	143	0.09		
	63 KOKOMO IN	67	0.10		
	64 LAFAYETTE-WEST LAFAYETTE IN	102	0.10		
	65 LANSING-EAST LANSING MI	118	0.16		
	66 LIMA OH	59	0.12		
	67 LORAIN-ELYRIA OH	156	0.14		
	68 MANSFIELD OH	139	0.13		
	69 MUNCIE IN	63	0.11		
	70 MUSKEGON-NORTON SHORES-MUSKEGO M	160	0.10		
	71 NEWARK OH	160	0.13		
	72 SOUTH BEND IN	72	0.12		
	73 SPRINGFIELD OH	106	0.12		
	74 TERRE HAUTE IN	163	0.10		
	75 TOLEDO OH-MI	92	0.19		
3	LYNCHBURG VA			5.20	10.89
	76 BURLINGTON NC	94	0.27		
	77 CHARLESTON WV	151	0.26		
	78 CHARLOTTESVILLE VA	56	0.21		
	79 CUMBERLAND MD-WV	156	0.21		
	80 DANVILLE VA	60	0.22		
	81 FAYETTEVILLE NC	164	0.22		
	82 GREENSBORO-WINSTON-SALEM-HIGH NC	100	0.34		
	83 GREENVILLE-SPARTANBURG SC	159	0.29		
	84 HAGERSTOWN MD	172	0.12		
	85 HICKORY NC	169	0.20		
	86 LYNCHBURG VA	0	0.23		
	87 NEWPORT NEWS-HAMPTON VA	152	0.25		
	88 NORFOLK-VIRGINIA BEACH-PORTSMO V	162	0.34		
	89 PETERSBURG-COLONIAL HEIGHTS-HO V	97	0.20		
	90 RALEIGH-DURHAM NC	116	0.30		
	91 RICHMOND VA	94	0.34		
	92 ROANOKE VA	45	0.25		
	93 SALISBURY-CONCORD NC	161	0.21		

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TABLE I-4. ESTABLISHED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	94 WASHINGTON DC-MD	154	0.75		
4	ERIE PA			5.33	16.23
	95 AKRON OH	103	0.36		
	96 ALTOONA PA	142	0.16		
	97 BUFFALO NY	81	0.59		
	98 CANTON OH	113	0.30		
	99 CLEVELAND OH	93	0.73		
	100 ELMIRA NY	169	0.11		
	101 ERIE PA	0	0.30		
	102 JOHNSTOWN PA	138	0.27		
	103 PITTSBURGH PA	117	0.80		
	104 ROCHESTER NY	144	0.52		
	105 SHARON PA	65	0.26		
	106 STATE COLLEGE PA	148	0.14		
	107 STEUBENVILLE-WEIRTON OH-WV	124	0.23		
	108 WHEELING WV-OH	146	0.23		
	109 YOUNGSTOWN-WARREN OH	76	0.33		
5	ROCKFORD IL			4.71	20.94
	110 APPLETON-OSHKOSH WI	141	0.23		
	111 BLOOMINGTON-NORMAL IL	123	0.20		
	112 CEDAR RAPIDS IA	133	0.22		
	113 CHAMPAIGN-URBANA-RANTOUL IL	154	0.22		
	114 DAVENPORT-ROCK ISLAND-MOLINE IA-	92	0.25		
	115 DECATUR IL	167	0.21		
	116 DUBUQUE IA	82	0.19		
	117 GREEN BAY WI	163	0.22		
	118 IOWA CITY IW	132	0.18		
	119 JANESVILLE-BELIOT WI	17	0.19		
	120 KENOSHA WI	69	0.19		
	121 LA CROSSE WI	153	0.18		
	122 MADISON WI	58	0.28		
	123 MILWAUKEE WI	79	0.59		
	124 PEORIA IL	111	0.26		
	125 RACINE WI	74	0.21		
	126 ROCKFORD IL	0	0.23		
	127 SHEBOYGAN WI	124	0.20		
	128 SPRINGFIELD IL	172	0.23		
	129 WATERLOO-CEDAR FALLS IA	167	0.23		
6	ATHENS GE			5.16	26.10
	130 ALBANY GA	170	0.21		
	131 ANDERSON SC	57	0.26		

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TABLE I-4. ESTABLISHED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	132 ANNISTON AL	143	0.23		
	133 ASHEVILLE NC	122	0.29		
	134 ATHENS GE	0	0.26		
	135 ATLANTA GA	60	0.95		
	136 AUGUSTA GA-SC	88	0.30		
	137 CHARLOTTE-GASTONIA NC	170	0.49		
	138 CHATTANOOGA TN-GA	133	0.37		
	139 COLUMBIA SC	135	0.37		
	140 COLUMBUS GA-AL	139	0.26		
	141 GADSDEN AL	151	0.23		
	142 KNOXVILLE TN	142	0.40		
	143 MACON GA	79	0.27		
	144 ROCK HILL SC	151	0.26		
7	BRYAN-COLLEGE STATION TX			3.89	29.99
	145 AUSTIN TX	87	0.28		
	146 BEAUMONT-PORT ARTHUR-ORANGE TX	142	0.22		
	147 BRYAN-COLLEGE STATION TX	0	0.16		
	148 DALLAS-FORT WORTH TX	147	0.84		
	149 GALVESTON-TEXAS CITY TX	134	0.18		
	150 HOUSTON TX	88	0.97		
	151 KILLEEN-TEMPLE TX	87	0.19		
	152 LONGVIEW TX	157	0.20		
	153 SAN ANTONIO TX	153	0.33		
	154 TYLER TX	131	0.19		
	155 VICTORIA TX	133	0.15		
	156 WACO TX	76	0.19		
8	LAKELAND-WINTER HAVEN FL			4.10	34.10
	157 BRADENTON FL	65	0.22		
	158 DAYTONA BEACH FL	93	0.27		
	159 FORT LAUDERDALE-HOLLYWOOD FL	164	0.39		
	160 FORT MYERS FL	97	0.23		
	161 GAINESVILLE FL	117	0.26		
	162 JACKSONVILLE FL	158	0.47		
	163 LAKELAND-WINTER HAVEN FL	0	0.26		
	164 MELBOURNE-TITUSVILLE-COCOA FL	66	0.26		
	165 OCALA FL	83	0.24		
	166 ORLANDO FL	42	0.39		
	167 SARASOTA FL	70	0.24		
	168 TAMPA-ST PETERSBURG FL	46	0.55		
	169 WEST PALM BEACH-BOCA RATON FL	138	0.32		
9	PORTLAND ME			4.22	38.31

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TABLE I-4. ESTABLISHED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	170 BANGOR ME	109	0.28		
	171 BOSTON MA	99	1.23		
	172 BROCKTON MA	117	0.23		
	173 BURLINGTON VT	158	0.32		
	174 GLENS FALLS NY	171	0.23		
	175 LAWRENCE-HAVERHILL MA-NH	91	0.27		
	176 LEWISTON-AUBURN ME	31	0.28		
	177 LOWELL MA-NH	89	0.26		
	178 MANCHESTER NH	76	0.27		
	179 NASHUA NH	87	0.23		
	180 PORTLAND ME	0	0.32		
	181 PORTSMOUTH-DOVER-ROCHESTER NH-ME	119	0.31		
10	EVANSVILLE IN-KY			4.22	42.53
	182 CLARKSVILLE-HOPKINSVILLE TN-KY	101	0.35		
	183 EVANSVILLE IN-KY	0	0.41		
	184 LEXINGTON-FAYETTE KY	168	0.46		
	185 LOUISVILLE KY-IN	101	0.75		
	186 NASHVILLE-DAVIDSON TN	133	0.72		
	187 OWENSBORO KY	29	0.32		
	188 ST LOUIS MO-IL	149	1.22		
11	VISALIA-TULARE-PORTERVILLE CA			4.10	46.64
	189 BAKERSFIELD CA	69	0.19		
	190 FRESNO CA	40	0.21		
	191 LOS ANGELES-LONG BEACH CA	170	2.19		
	192 MODESTO CA	132	0.16		
	193 OXNARD-SIMI VALLEY-VENTURA CA	148	0.18		
	194 SALINAS-SEASIDE-MONTEREY CA	134	0.15		
	195 SAN JOSE CA	161	0.36		
	196 SANTA BARBARA-SANTA MARIA-LOMP C	135	0.18		
	197 SANTA CRUZ CA	159	0.15		
	198 STOCKTON CA	158	0.17		
	199 VISALIA-TULARE-PORTERVILLE CA	0	0.16		
12	LAWRENCE KS			4.27	50.90
	200 COLUMBIA MO	157	0.32		
	201 JOPLIN MO	135	0.32		
	202 KANSAS CITY MO-KS	37	0.95		
	203 LAWRENCE KS	0	0.30		
	204 LINCOLN NE	149	0.37		
	205 OMAHA NE-IA	162	0.54		
	206 ST JOSEPH MO	59	0.31		
	207 SPRINGFIELD MO	160	0.37		

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TABLE I-4. ESTABLISHED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	208 TOPEKA KS	25	0.36		
	209 WICHITA KS	143	0.44		
13	JACKSON MS			4.10	55.01
	210 ALEXANDRIA LA	150	0.30		
	211 BATON ROUGE LA	140	0.47		
	212 BILOXI-GULFPORT MS	151	0.32		
	213 JACKSON MS	0	0.47		
	214 MOBILE AL	168	0.44		
	215 MONROE LA	113	0.33		
	216 NEW ORLEANS LA	162	0.80		
	217 PASCAGOULA-MOSS POINT PATERSON M	165	0.31		
	218 PINE BLUFF AR	169	0.32		
	219 TUSCALOOSA AL	166	0.34		
14	EAU CLAIRE WI			3.40	58.41
	220 DULUTH-SUPERIOR MN-WI	139	0.43		
	221 EAU CLAIRE WI	0	0.34		
	222 MINNEAPOLIS-ST PAUL MN-WI	88	1.63		
	223 ROCHESTER MN	72	0.36		
	224 ST CLOUD MN	141	0.33		
	225 WAUSAU WI	93	0.31		
15	MONTGOMERY AL			2.75	61.16
	226 BIRMINGHAM AL	84	0.77		
	227 FORT WALTON BEACH FL	137	0.33		
	228 HUNTSVILLE AL	163	0.48		
	229 MONTGOMERY AL	0	0.43		
	230 PANAMA CITY FL	157	0.33		
	231 PENSACOLA FL	145	0.40		
16	CHICO CA			2.74	63.89
	232 CHICO CA	0	0.20		
	233 REDDING CA	66	0.19		
	234 RENO NV	110	0.24		
	235 SACRAMENTO CA	83	0.42		
	236 SAN FRANCISCO-OAKLAND CA	139	1.03		
	237 SANTA ROSA CA	102	0.22		
	238 VALLEJO-FAIRFIELD-NAPA CA	116	0.22		
	239 YUBA CITY CA	42	0.19		

TABLE I-4. ESTABLISHED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
17 YAKIMA WA			2.86	66.75
240 BREMERTON WA	121	0.21		
241 OLYMPIA WA	117	0.20		
242 PORTLAND OR-WA	129	0.54		
243 RICHLAND-KENNEWICK WA	63	0.22		
244 SALEM OR	168	0.24		
245 SEATTLE-EVERETT WA	111	0.65		
246 SPOKANE WA	163	0.29		
247 TACOMA WA	102	0.29		
248 YAKIMA WA	0	0.22		
18 OKLAHOMA CITY OK			2.77	69.52
249 ENID OK	67	0.31		
250 LAWTON OK	78	0.32		
251 OKLAHOMA CITY OK	0	0.79		
252 SHERMAN-DENISON TX	136	0.31		
253 TULSA OK	99	0.69		
254 WICHITA FALLS TX	121	0.33		
19 FORT COLLINS CO			2.72	72.24
255 CASPER WY	168	0.27		
256 COLORADO SPRINGS CO	121	0.40		
257 DENVER-BOULDER CO	58	1.15		
258 FORT COLLINS CO	0	0.30		
259 GREELEY CO	23	0.30		
260 PUEBLO CO	161	0.30		
20 LITTLE ROCK-NORTH LITTLE ROCK AR			2.75	74.99
261 FAYETTEVILLE-SPRINGDALE AR	139	0.40		
262 FORT SMITH AR-OK	129	0.43		
263 LITTLE ROCK-NORTH LITTLE ROCK AR	0	0.61		
264 MEMPHIS TN-AR	130	0.94		
265 TEXARKANA TX-AR	136	0.36		

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TABLE I-5. TEN EARTH STATION NETWORK REPORT

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
1	NEW YORK NY-NJ			10.02	10.02
	1 ALBANY-SCHENECTADY-TROY NY	134	0.20		
	2 ALLENTOWN-BETHLEHEM-EASTON PA-NJ	78	0.20		
	3 ATLANTIC CITY NJ	99	0.12		
	4 BALTIMORE MD	171	0.50		
	5 BINGHAMTON NY-PA	138	0.14		
	6 BRIDGEPORT CT	52	0.20		
	7 BRISTOL CT	85	0.09		
	8 DANBURY CT	54	0.11		
	9 FALL RIVER MA-RI	162	0.10		
	10 FITCHBURG-LEOMINSTER MA	171	0.09		
	11 HARRISBURG PA	156	0.18		
	12 HARTFORD CT	99	0.23		
	13 JERSEY CITY NJ	3	0.16		
	14 LANCASTER PA	131	0.14		
	15 LONG BRANCH-ASBURY PARK NJ	31	0.16		
	16 MERIDEN CT	83	0.09		
	17 NASSAU-SUFFOLK NY	20	0.48		
	18 NEW BEDFORD MA	171	0.11		
	19 NEW BRITAIN CT	90	0.10		
	20 NEW BRUNSWICK-PERTH AMBOY-SAYR N	30	0.19		
	21 NEW HAVEN-WEST HAVEN CT	68	0.19		
	22 NEW LONDON-NORWICH CT-RI	108	0.12		
	23 NEW YORK NY-NJ	0	2.45		
	24 NEWARK NJ	10	0.38		
	25 NEWBRGH-MIDDLETOWN NY	55	0.12		
	26 NORTHEAST PENNSYLVANIA PA	102	0.20		
	27 NORWALK CT	39	0.11		
	28 PATERSON-CLIFTON-PASSAIC NJ	16	0.14		
	29 PHILADELPHIA PA-NJ	82	0.89		
	30 PITTSFIELD MA	125	0.10		
	31 POUGHKEEPSIE NY	68	0.13		
	32 PROVIDENCE-WARWICK-PAWTUCKET RI-	154	0.21		
	33 READING PA	106	0.14		
	34 SPRINGFIELD-CHICOPEE-HOLYOKE CT-	120	0.17		
	35 STAMFORD CT	33	0.13		
	36 TRENTON NJ	54	0.16		
	37 VINELAND-MILLVILLE-BRIDGETON NJ	103	0.11		
	38 WATERBURY CT	75	0.12		
	39 WILLIAMSPORT PA	162	0.11		
	40 WILMINGTON DE-NJ	107	0.19		
	41 WORCESTER MA	155	0.14		
	42 YORK PA	154	0.14		
2	FORT WAYNE IN			8.09	18.11
	43 ANDERSON IN	74	0.13		
	44 ANN ARBOR MI	111	0.17		
	45 BATTLE CREEK MI	86	0.14		

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TABLE I-5. TEN EARTH STATION NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	46 BENTON HARBOR MI	99	0.14		
	47 BLOOMINGTON IN	151	0.13		
	48 CHICAGO IL	142	1.43		
	49 CINCINNATI OH-KY	140	0.44		
	50 COLUMBUS OH	136	0.36		
	51 DAYTON OH	103	0.27		
	52 DETROIT MI	138	0.93		
	53 ELKHART IN	61	0.13		
	54 FLINT MI	153	0.20		
	55 FORT WAYNE IN	0	0.19		
	56 GARY-HAMMOND-EAST CHICAGO IN	121	0.18		
	57 GRAND RAPIDS MI	133	0.22		
	58 HAMILTON-MIDDLETOWN OH	119	0.16		
	59 INDIANAPOLIS IN	105	0.37		
	60 JACKSON MI	89	0.14		
	61 KALAMAZOO-PORTAGE MI	87	0.16		
	62 KANKAKEE IL	143	0.11		
	63 KOKOMO IN	67	0.13		
	64 LAFAYETTE-WEST LAFAYETTE IN	102	0.13		
	65 LANSING-EAST LANSING MI	118	0.22		
	66 LIMA OH	59	0.15		
	67 LORAIN-ELYRIA OH	156	0.16		
	68 MANSFIELD OH	139	0.15		
	69 MUNCIE IN	63	0.14		
	70 MUSKEGON-NORTON SHORES-MUSKEGO M	160	0.14		
	71 NEWARK OH	160	0.15		
	72 SOUTH BEND IN	72	0.16		
	73 SPRINGFIELD OH	106	0.15		
	74 TERRE HAUTE IN	163	0.13		
	75 TOLEDO OH-MI	92	0.26		
3	LYNCHBURG VA			4.69	22.80
	76 BURLINGTON NC	94	0.23		
	77 CHARLESTON WV	151	0.21		
	78 CHARLOTTESVILLE VA	56	0.17		
	79 CUMBERLAND MD-WV	156	0.16		
	80 DANVILLE VA	60	0.18		
	81 FAYETTEVILLE NC	164	0.19		
	82 GREENSBORO-WINSTON-SALEM-HIGH NC	100	0.30		
	83 GREENVILLE-SPARTANBURG SC	159	0.25		
	84 HAGERSTOWN MD	172	0.12		
	85 HICKORY NC	169	0.17		
	86 LYNCHBURG VA	0	0.19		
	87 NEWPORT NEWS-HAMPTON VA	152	0.22		
	88 NORFOLK-VIRGINIA BEACH-PORTSMO V	162	0.31		
	89 PETERSBURG-COLONIAL HEIGHTS-HO V	97	0.17		
	90 RALEIGH-DURHAM NC	116	0.27		
	91 RICHMOND VA	94	0.32		
	92 ROANOKE VA	45	0.20		
	93 SALISBURY-CONCORD NC	161	0.18		

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TABLE I-5. TEN EARTH STATION NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	94 WASHINGTON DC-MD	154	0.83		
4	ERIE PA			4.18	26.97
	95 AKRON OH	103	0.29		
	96 ALTOONA PA	142	0.13		
	97 BUFFALO NY	81	0.44		
	98 CANTON OH	113	0.23		
	99 CLEVELAND OH	93	0.63		
	100 ELMIRA NY	169	0.10		
	101 ERIE PA	0	0.22		
	102 JOHNSTOWN PA	138	0.20		
	103 PITTSBURGH PA	117	0.67		
	104 ROCHESTER NY	144	0.38		
	105 SHARON PA	65	0.18		
	106 STATE COLLEGE PA	148	0.12		
	107 STEUBENVILLE-WEIRTON OH-WV	124	0.17		
	108 WHEELING WV-OH	146	0.17		
	109 YOUNGSTOWN-WARREN OH	76	0.25		
5	ROCKFORD IL			3.31	30.29
	110 APPLETON-OSHKOSH WI	141	0.16		
	111 BLOOMINGTON-NORMAL IL	123	0.14		
	112 CEDAR RAPIDS IA	133	0.15		
	113 CHAMPAIGN-URBANA-RANTOUL IL	154	0.15		
	114 DAVENPORT-ROCK ISLAND-MOLINE IA-	92	0.18		
	115 DECATUR IL	167	0.14		
	116 DUBUQUE IA	82	0.14		
	117 GREEN BAY WI	163	0.15		
	118 IOWA CITY IW	132	0.12		
	119 JANESVILLE-BELIOT WI	17	0.14		
	120 KENOSHA WI	69	0.14		
	121 LA CROSSE WI	153	0.13		
	122 MADISON WI	58	0.20		
	123 MILWAUKEE WI	79	0.43		
	124 PEORIA IL	111	0.19		
	125 RACINE WI	74	0.15		
	126 ROCKFORD IL	0	0.17		
	127 SHEBOYGAN WI	124	0.14		
	128 SPRINGFIELD IL	172	0.16		
	129 WATERLOO-CEDAR FALLS IA	167	0.15		
6	ATHENS GE			3.34	33.62
	130 ALBANY GA	170	0.14		
	131 ANDERSON SC	57	0.17		

TABLE I-5. TEN EARTH STATION NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	132 ANNISTON AL	143	0.15		
	133 ASHEVILLE NC	122	0.18		
	134 ATHENS GE	0	0.17		
	135 ATLANTA GA	60	0.63		
	136 AUGUSTA GA-SC	88	0.20		
	137 CHARLOTTE-GASTONIA NC	170	0.31		
	138 CHATTANOOGA TN-GA	133	0.23		
	139 COLUMBIA SC	135	0.24		
	140 COLUMBUS GA-AL	139	0.18		
	141 GADSDEN AL	151	0.15		
	142 KNOXVILLE TN	142	0.25		
	143 MACON GA	79	0.17		
	144 ROCK HILL SC	151	0.16		
7	BRYAN-COLLEGE STATION TX			2.35	35.98
	145 AUSTIN TX	[illegible]	0.17		
	146 BEAUMONT-PORT ARTHUR-ORANGE TX	[illegible]	0.13		
	147 BRYAN-COLLEGE STATION TX	0	0.10		
	148 DALLAS-FORT WORTH TX	147	0.51		
	149 GALVESTON-TEXAS CITY TX	134	0.11		
	150 HOUSTON TX	88	0.60		
	151 KILLEEN-TEMPLE TX	87	0.11		
	152 LONGVIEW TX	157	0.12		
	153 SAN ANTONIO TX	153	0.20		
	154 TYLER TX	131	0.11		
	155 VICTORIA TX	133	0.09		
	156 WACO TX	76	0.11		
8	LAKELAND-WINTER HAVEN FL			2.25	38.23
	157 BRADENTON FL	65	0.12		
	158 DAYTONA BEACH FL	93	0.15		
	159 FORT LAUDERDALE-HOLLYWOOD FL	164	0.22		
	160 FORT MYERS FL	97	0.12		
	161 GAINESVILLE FL	117	0.14		
	162 JACKSONVILLE FL	158	0.26		
	163 LAKELAND-WINTER HAVEN FL	0	0.14		
	164 MELBOURNE-TITUSVILLE-COCOA FL	66	0.14		
	165 OCALA FL	83	0.13		
	166 ORLANDO FL	42	0.21		
	167 SARASOTA FL	70	0.13		
	168 TAMPA-ST PETERSBURG FL	46	0.30		
	169 WEST PALM BEACH-BOCA RATON FL	138	0.18		
9	PORTLAND ME			2.19	40.42

TABLE I-5. TEN EARTH STATION NETWORK REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
170 BANGOR ME	109	0.14		
171 BOSTON MA	99	0.64		
172 BROCKTON MA	117	0.12		
173 BURLINGTON VT	158	0.16		
174 GLENS FALLS NY	171	0.12		
175 LAWRENCE-HAVERHILL MA-NH	81	0.14		
176 LEWISTON-AUBURN ME	31	0.15		
177 LOWELL MA-NH	89	0.13		
178 MANCHESTER NH	76	0.14		
179 NASHUA NH	87	0.12		
180 PORTLAND ME	0	0.17		
181 PORTSMOUTH-DOVER-ROCHESTER NH-ME	119	0.16		
10 EVANSVILLE IN-KY			2.11	42.53
182 CLARKSVILLE-HOPKINSVILLE TN-KY	101	0.17		
183 EVANSVILLE IN-KY	0	0.20		
184 LEXINGTON-FAYETTE KY	168	0.23		
185 LOUISVILLE KY-IN	101	0.37		
186 NASHVILLE-DAVIDSON TN	133	0.36		
187 OWENSBORO KY	29	0.16		
188 ST LOUIS MO-IL	149	0.61		

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TABLE I-6. TWENTY EARTH STATION NETWORK REPORT

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
1 NEW YORK NY-NJ			13.13	13.13
1 ALBANY-SCHENECTADY-TROY NY	134	0.26		
2 ALLENTOWN-BETHLEHEM-EASTON PA-NJ	78	0.25		
3 ATLANTIC CITY NJ	99	0.16		
4 BALTIMORE MD	171	0.66		
5 BINGHAMTON NY-PA	138	0.18		
6 BRIDGEPORT CT	52	0.25		
7 BRISTOL CT	85	0.12		
8 DANBURY CT	54	0.14		
9 FALL RIVER MA-RI	162	0.13		
10 FITCHBURG-LEOMINSTER MA	171	0.12		
11 HARRISBURG PA	156	0.24		
12 HARTFORD CT	99	0.30		
13 JERSEY CITY NJ	3	0.22		
14 LANCASTER PA	131	0.19		
15 LONG BRANCH-ASBURY PARK NJ	31	0.21		
16 MERIDEN CT	83	0.12		
17 NASSAU-SUFFOLK NY	20	0.63		
18 NEW BEDFORD MA	171	0.14		
19 NEW BRITAIN CT	90	0.13		
20 NEW BRUNSWICK-PERTH AMBOY-SAYR N	30	0.24		
21 NEW HAVEN-WEST HAVEN CT	68	0.25		
22 NEW LONDON-NORWICH CT-RI	108	0.16		
23 NEW YORK NY-NJ	0	3.21		
24 NEWARK NJ	10	0.49		
25 NEWBRGH-MIDDLETOWN NY	55	0.16		
26 NORTHEAST PENNSYLVANIA PA	102	0.26		
27 NORWALK CT	39	0.14		
28 PATERSON-CLIFTON-PASSAIC NJ	16	0.19		
29 PHILADELPHIA PA-NJ	82	1.15		
30 PITTSFIELD MA	125	0.13		
31 POUGHKEEPSIE NY	68	0.16		
32 PROVIDENCE-WARWICK-PAWTUCKET RI-	154	0.28		
33 READING PA	106	0.19		
34 SPRINGFIELD-CHICOPEE-HOLYOKE CT-	120	0.23		
35 STAMFORD CT	33	0.17		
36 TRENTON NJ	54	0.20		
37 VINELAND-MILLVILLE-BRIDGETON NJ	103	0.14		
38 WATERBURY CT	75	0.15		
39 WILLIAMSPORT PA	162	0.15		
40 WILMINGTON DE-NJ	107	0.24		
41 WORCESTER MA	155	0.18		
42 YORK PA	154	0.18		
2 FORT WAYNE IN			11.03	24.16
43 ANDERSON IN	74	0.18		
44 ANN ARBOR MI	111	0.23		
45 BATTLE CREEK MI	86	0.19		

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TABLE I-6. TWENTY EARTH STATION NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	46 BENTON HARBOR MI	99	0.19		
	47 BLOOMINGTON IN	151	0.18		
	48 CHICAGO IL	142	2.10		
	49 CINCINNATI OH-KY	140	0.59		
	50 COLUMBUS OH	136	0.48		
	51 DAYTON OH	103	0.37		
	52 DETROIT MI	138	1.23		
	53 ELKHART IN	61	0.18		
	54 FLINT MI	153	0.26		
	55 FORT WAYNE IN	0	0.26		
	56 GARY-HAMMOND-EAST CHICAGO IN	121	0.25		
	57 GRAND RAPIDS MI	133	0.30		
	58 HAMILTON-MIDDLETOWN OH	119	0.21		
	59 INDIANAPOLIS IN	105	0.51		
	60 JACKSON MI	89	0.19		
	61 KALAMAZOO-PORTAGE MI	87	0.22		
	62 KANKAKEE IL	143	0.16		
	63 KOKOMO IN	67	0.18		
	64 LAFAYETTE-WEST LAFAYETTE IN	102	0.18		
	65 LANSING-EAST LANSING MI	118	0.30		
	66 LIMA OH	59	0.20		
	67 LORAIN-ELYRIA OH	156	0.20		
	68 MANSFIELD OH	139	0.20		
	69 MUNCIE IN	63	0.19		
	70 MUSKEGON-NORTON SHORES-MUSKEGO M	160	0.19		
	71 NEWARK OH	160	0.19		
	72 SOUTH BEND IN	72	0.22		
	73 SPRINGFIELD OH	106	0.19		
	74 TERRE HAUTE IN	163	0.19		
	75 TOLEDO OH-MI	92	0.34		
3	LYNCHBURG VA			5.82	29.98
	76 BURLINGTON NC	94	0.29		
	77 CHARLESTON WV	151	0.27		
	78 CHARLOTTESVILLE VA	56	0.21		
	79 CUMBERLAND MD-WV	156	0.19		
	80 DANVILLE VA	60	0.21		
	81 FAYETTEVILLE NC	164	0.24		
	82 GREENSBORO-WINSTON-SALEM-HIGH NC	100	0.38		
	83 GREENVILLE-SPARTANBURG SC	159	0.31		
	84 HAGERSTOWN MD	172	0.15		
	85 HICKORY NC	169	0.21		
	86 LYNCHBURG VA	0	0.23		
	87 NEWPORT NEWS-HAMPTON VA	152	0.27		
	88 NORFOLK-VIRGINIA BEACH-PORTSMO V	162	0.38		
	89 PETERSBURG-COLONIAL HEIGHTS-HO V	97	0.20		
	90 RALEIGH-DURHAM NC	116	0.33		
	91 RICHMOND VA	94	0.39		
	92 ROANOKE VA	45	0.25		
	93 SALISBURY-CONCORD NC	161	0.22		

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TABLE I-6. TWENTY EARTH STATION NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	94 WASHINGTON DC-MD	154	1.07		
4	ERIE PA			5.20	35.18
	95 AKRON OH	103	0.36		
	96 ALTOONA PA	142	0.17		
	97 BUFFALO NY	81	0.53		
	98 CANTON OH	113	0.28		
	99 CLEVELAND OH	93	0.30		
	100 ELMIRA NY	169	0.14		
	101 ERIE PA	0	0.27		
	102 JOHNSTOWN PA	138	0.24		
	103 PITTSBURGH PA	117	0.84		
	104 ROCHESTER NY	144	0.46		
	105 SHARON PA	65	0.22		
	106 STATE COLLEGE PA	148	0.16		
	107 STEUBENVILLE-WEIRTON OH-WV	124	0.22		
	108 WHEELING WV-OH	146	0.21		
	109 YOUNGSTOWN-WARREN OH	76	0.30		
5	ROCKFORD IL			4.53	39.71
	110 APPLETON-OSHKOSH WI	141	0.21		
	111 BLOOMINGTON-NORMAL IL	123	0.19		
	112 CEDAR RAPIDS IA	133	0.21		
	113 CHAMPAIGN-URBANA-RANTOUL IL	154	0.21		
	114 DAVENPORT-ROCK ISLAND-MOLINE IA-	92	0.25		
	115 DECATUR IL	167	0.20		
	116 DUBUQUE IA	82	0.18		
	117 GREEN BAY WI	163	0.20		
	118 IOWA CITY IW	132	0.17		
	119 JANESVILLE-BELIOT WI	17	0.19		
	120 KENOSHA WI	69	0.19		
	121 LA CROSSE WI	153	0.17		
	122 MADISON WI	58	0.26		
	123 MILWAUKEE WI	79	0.60		
	124 PEORIA IL	111	0.26		
	125 RACINE WI	74	0.20		
	126 ROCKFORD IL	0	0.23		
	127 SHEBOYGAN WI	124	0.18		
	128 SPRINGFIELD IL	172	0.23		
	129 WATERLOO-CEDAR FALLS IA	167	0.20		
6	ATHENS GE			4.28	43.99
	130 ALBANY GA	170	0.18		
	131 ANDERSON SC	57	0.21		

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TABLE I-6. TWENTY EARTH STATION NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	132 ANNISTON AL	143	0.20		
	133 ASHEVILLE NC	122	0.23		
	134 ATHENS GE	0	0.21		
	135 ATLANTA GA	60	0.83		
	136 AUGUSTA GA-SC	86	0.25		
	137 CHARLOTTE-GASTONIA NC	170	0.40		
	138 CHATTANOOGA TN-GA	133	0.30		
	139 COLUMBIA SC	135	0.31		
	140 COLUMBUS GA-AL	139	0.22		
	141 GADSDEN AL	151	0.19		
	142 KNOXVILLE TN	142	0.32		
	143 MACON GA	79	0.22		
	144 ROCK HILL SC	151	0.20		
7	BRYAN-COLLEGE STATION TX			3.59	47.57
	145 AUSTIN TX	87	0.26		
	146 BEAUMONT-PORT ARTHUR-ORANGE TX	142	0.20		
	147 BRYAN-COLLEGE STATION TX	0	0.15		
	148 DALLAS-FORT WORTH TX	147	0.77		
	149 GALVESTON-TEXAS CITY TX	134	0.16		
	150 HOUSTON TX	88	0.92		
	151 KILLEEN-TEMPLE TX	87	0.17		
	152 LONGVIEW TX	157	0.17		
	153 SAN ANTONIO TX	153	0.31		
	154 TYLER TX	131	0.17		
	155 VICTORIA TX	133	0.13		
	156 WACO TX	76	0.17		
8	LAKELAND-WINTER HAVEN FL			2.98	50.56
	157 BRADENTON FL	65	0.16		
	158 DAYTONA BEACH FL	93	0.19		
	159 FORT LAUDERDALE-HOLLYWOOD FL	164	0.29		
	160 FORT MYERS FL	97	0.16		
	161 GAINESVILLE FL	117	0.19		
	162 JACKSONVILLE FL	158	0.34		
	163 LAKELAND-WINTER HAVEN FL	0	0.19		
	164 MELBOURNE-TITUSVILLE-COCOA FL	66	0.19		
	165 OCALA FL	83	0.17		
	166 ORLANDO FL	42	0.28		
	167 SARASOTA FL	70	0.18		
	168 TAMPA-ST PETERSBURG FL	46	0.41		
	169 WEST PALM BEACH-BOCA RATON FL	138	0.23		
9	PORTLAND ME			2.73	53.28

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TABLE I-6. TWENTY EARTH STATION NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	170 BANGOR ME	109	0.17		
	171 BOSTON MA	99	0.82		
	172 BROCKTON MA	117	0.15		
	173 BURLINGTON VT	158	0.20		
	174 GLENS FALLS NY	171	0.15		
	175 LAWRENCE-HAVERHILL MA-NH	81	0.18		
	176 LEWISTON-AUBURN ME	31	0.17		
	177 LOWELL MA-NH	89	0.17		
	178 MANCHESTER NH	76	0.18		
	179 NASHUA NH	87	0.15		
	180 PORTLAND ME	0	0.20		
	181 PORTSMOUTH-DOVER-ROCHESTER NH-ME	119	0.19		
10	EVANSVILLE IN-KY			2.80	56.08
	182 CLARKSVILLE-HOPKINSVILLE TN-KY	101	0.22		
	183 EVANSVILLE IN-KY	0	0.27		
	184 LEXINGTON-FAYETTE KY	168	0.29		
	185 LOUISVILLE KY-IN	101	0.49		
	186 NASHVILLE-DAVIDSON TN	133	0.47		
	187 OWENSBORO KY	29	0.21		
	188 ST LOUIS MO-IL	149	0.85		
11	VISALIA-TULARE-PORTERVILLE CA			3.07	59.15
	189 BAKERSFIELD CA	69	0.14		
	190 FRESNO CA	40	0.15		
	191 LOS ANGELES-LONG BEACH CA	170	1.70		
	192 MODESTO CA	132	0.11		
	193 OXNARD-SIMI VALLEY-VENTURA CA	143	0.14		
	194 SALINAS-SEASIDE-MONTEREY CA	134	0.10		
	195 SAN JOSE CA	161	0.25		
	196 SANTA BARBARA-SANTA MARIA-LOMP C	135	0.13		
	197 SANTA CRUZ CA	159	0.10		
	198 STOCKTON CA	158	0.12		
	199 VISALIA-TULARE-PORTERVILLE CA	0	0.11		
12	LAWRENCE KS			2.67	61.82
	200 COLUMBIA MO	157	0.20		
	201 JOPLIN MO	135	0.19		
	202 KANSAS CITY MO-KS	37	0.60		
	203 LAWRENCE KS	0	0.18		
	204 LINCOLN NE	149	0.23		
	205 OMAHA NE-IA	162	0.35		
	206 ST JOSEPH MO	59	0.19		
	207 SPRINGFIELD MO	160	0.22		

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TABLE I-6. TWENTY EARTH STATION NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	208 TOPEKA KS	25	0.23		
	209 WICHITA KS	143	0.27		
13	JACKSON MS			2.39	64.21
	210 ALEXANDRIA LA	150	0.18		
	211 BATON ROUGE LA	140	0.28		
	212 BILOXI-GULFPORT MS	151	0.18		
	213 JACKSON MS	0	0.27		
	214 MOBILE AL	168	0.25		
	215 MONROE LA	113	0.19		
	216 NEW ORLEANS LA	162	0.48		
	217 PASCAGOULA-MOSS POINT PATERSON M	165	0.18		
	218 PINE BLUFF AR	169	0.19		
	219 TUSCALOOSA AL	166	0.19		
14	EAU CLAIRE WI			1.93	66.14
	220 DULUTH-SUPERIOR MN-WI	139	0.24		
	221 EAU CLAIRE WI	0	0.19		
	222 MINNEAPOLIS-ST PAUL MN-WI	88	0.93		
	223 ROCHESTER MN	72	0.20		
	224 ST CLOUD MN	141	0.19		
	225 WAUSAU WI	93	0.18		
15	MONTGOMERY AL			1.50	67.64
	226 BIRMINGHAM AL	84	0.42		
	227 FORT WALTON BEACH FL	137	0.18		
	228 HUNTSVILLE AL	163	0.26		
	229 MONTGOMERY AL	0	0.24		
	230 PANAMA CITY FL	157	0.18		
	231 PENSACOLA FL	145	0.22		
16	CHICO CA			1.59	69.24
	232 CHICO CA	0	0.12		
	233 REDDING CA	66	0.11		
	234 RENO NV	110	0.14		
	235 SACRAMENTO CA	83	0.25		
	236 SAN FRANCISCO-OAKLAND CA	139	0.61		
	237 SANTA ROSA CA	102	0.13		
	238 VALLEJO-FAIRFIELD-NAPA CA	116	0.13		
	239 YUBA CITY CA	42	0.11		

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TABLE I-6. TWENTY EARTH STATION NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
17	YAKIMA WA			1.53	70.77
	240 BREMERTON WA	121	0.11		
	241 OLYMPIA WA	117	0.11		
	242 PORTLAND OR-WA	129	0.29		
	243 RICHLAND-KENNEWICK WA	63	0.12		
	244 SALEM OR	168	0.13		
	245 SEATTLE-EVERETT WA	111	0.35		
	246 SPOKANE WA	163	0.16		
	247 TACOMA WA	102	0.15		
	248 YAKIMA WA	0	0.12		
18	OKLAHOMA CITY OK			1.45	72.22
	249 ENID OK	67	0.16		
	250 LAWTON OK	78	0.17		
	251 OKLAHOMA CITY OK	0	0.42		
	252 SHERMAN-DENISON TX	136	0.16		
	253 TULSA OK	99	0.36		
	254 WICHITA FALLS TX	121	0.18		
19	FORT COLLINS CO			1.39	73.61
	255 CASPER WY	168	0.14		
	256 COLORADO SPRINGS CO	121	0.20		
	257 DENVER-BOULDER CO	58	0.59		
	258 FORT COLLINS CO	0	0.15		
	259 GREELEY CO	23	0.15		
	260 PUEBLO CO	161	0.15		
20	LITTLE ROCK-NORTH LITTLE ROCK AR			1.37	74.98
	261 FAYETTEVILLE-SPRINGDALE AR	139	0.20		
	262 FORT SMITH AR-OK	129	0.22		
	263 LITTLE ROCK-NORTH LITTLE ROCK AR	0	0.31		
	264 MEMPHIS TN-AR	130	0.47		
	265 TEXARKANA TX-AR	136	0.18		

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TABLE I-7. SUMMARY NETWORK OPTIMIZATION REPORT

		NO. SMSA'S	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
1	NEW YORK NY-NJ	20		
2	CANTON OH	9	1.33	1.33
3	RACINE WI	5	1.21	2.54
4	JACKSON MI	6	0.93	3.47
5	SPRINGFIELD-CHICOPEE-HOLYOKE CT-MA	12	1.16	4.63
6	HAGERSTOWN MD	3	1.81	6.43
7	MUNCIE IN	6	1.15	7.58
8	GREENSBORO-WINSTON-SALEM-HIGH NC	7	1.92	9.50
9	ANNISTON AL	5	1.44	10.94
10	SPRINGFIELD IL	5	1.36	12.30
11	DUBUQUE IA	6	1.18	13.48
12	OXNARD-SIMI VALLEY-VENTURA CA	4	1.44	14.92
13	STOCKTON CA	6	1.42	16.34
14	PETERSBURG-COLONIAL HEIGHTS-HO VA	5	1.64	17.97
15	LAKELAND-WINTER HAVEN FL	4	1.10	19.07
16	ELMIRA NY	6	1.67	20.74
17	LEXINGTON-FAYETTE KY	3	1.64	22.38
18	ROCHESTER MN	4	1.62	24.01
19	ASHEVILLE NC	5	1.66	25.67
20	LIMA OH	4	1.59	27.25
21	BEAUMONT-PORT ARTHUR-ORANGE TX	4	1.58	28.83
22	KANSAS CITY MO-KS	4	1.53	30.36
23	BENTON HARBOR MI	5	1.51	31.87
24	BILOXI-GULFPORT MS	4	1.44	33.31
25	JACKSONVILLE NC	4	1.45	34.76
26	PARKERSBURG-MARIETTA WV-OH	4	1.46	36.22
27	COLUMBIA SC	4	1.46	37.68
28	DENVER-BOULDER CO	4	1.46	39.14
29	FORT LAUDERDALE-HOLLYWOOD FL	3	1.48	40.62
30	OCALA FL	4	1.44	42.05
31	COLUMBUS GA-AL	4	1.41	43.46
32	DALLAS-FORT WORTH TX	2	1.37	44.83
33	PROVIDENCE-WARWICK-PAWTUCKET RI-MA	4	1.32	46.16
34	TERRE HAUTE IN	4	1.33	47.49
35	BUFFALO NY	2	1.31	48.80
36	GLENS FALLS NY	4	1.34	50.14
37	APPLETON-OSHKOSH WI	4	1.35	51.48
38	BREMERTON WA	4	1.17	52.65
39	VINELAND-MILLVILLE-BRIDGETON NJ	4	1.31	53.96
40	LONGVIEW TX	4	1.28	55.24
41	LAWTON OK	3	1.28	56.52
42	AUSTIN TX	3	1.29	57.81
43	CLARKSVILLE-HOPKINSVILLE TN-KY	2	1.25	59.06
44	BAY CITY MI	3	1.24	60.30
45	JOPLIN MO	3	1.15	61.45
46	LAFAYETTE LA	3	1.15	62.60
47	FORT WALTON BEACH FL	3	1.10	63.70
48	LINCOLN NE	2	1.07	64.77
49	SALEM OR	3	1.00	65.78
50	BRADENTON FL	3	0.96	66.74
51	CHARLESTON-NORTH CHARLESTON SC	2	0.97	67.70
52	LITTLE ROCK-NORTH LITTLE ROCK AR	2	0.96	68.66
53	EVANSVILLE IN-KY	2	0.93	69.59

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TABLE I-7. SUMMARY NETWORK OPTIMIZATION REPORT (CONTINUED)

		NO. SMSA'S	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
54	MEMPHIS TN-AR	1	0.91	70.50
55	PROVO-OREM UT	2	0.85	71.35
56	VISALIA-TULARE-PORTERVILLE CA	3	0.78	72.13
57	PHOENIX AZ	1	0.78	72.91
58	CEDAR RAPIDS IA	2	0.76	73.67
59	LEWISTON-AUBURN ME	2	0.76	74.43
60	YUBA CITY CA	3	0.74	75.17
61	SAN DIEGO CA	1	0.75	75.92
62	SIOUX CITY NE-IA	2	0.74	76.67
63	BANGOR ME	2	0.74	77.40
64	TULSA OK	1	0.72	78.13
65	EL PASO TX	2	0.72	78.84
66	FARGO-MOORHEAD ND-MN	2	0.70	79.54
67	MIDLAND TX	2	0.68	80.21
68	CORPUS CHRISTI TX	2	0.67	80.89
69	ALTOONA PA	2	0.67	81.56
70	BROWNSVILLE-HARLINGEN-SAN BENI TX	2	0.67	82.23
71	BRYAN-COLLEGE STATION TX	2	0.66	82.89
72	ABILENE TX	2	0.66	83.55
73	CHATTANOOGA TN-GA	1	0.64	84.19
74	DES MOINES IA	1	0.64	84.83
75	WICHITA KS	1	0.59	85.42
76	JACKSON MS	1	0.57	85.99
77	SALINAS-SEASIDE-MONTEREY CA	2	0.55	86.54
78	DULUTH-SUPERIOR MN-WI	1	0.52	87.06
79	RICHLAND-KENNEWICK WA	2	0.51	87.57
80	ALBUQUERQUE NM	1	0.51	88.08
81	RIVERSIDE-SAN BERNARDINO-ONTAR CA	1	0.51	88.59
82	HAMILTON-MIDDLETOWN OH	1	0.50	89.09
83	LORAIN-ELYRIA OH	1	0.48	89.57
84	LYNCHBURG VA	1	0.48	90.05
85	LAS VEGAS NV	1	0.48	90.52
86	TUCSON AZ	1	0.48	91.00
87	FORT SMITH AR-OK	1	0.48	91.48
88	ATHENS GE	1	0.45	91.93
89	FLORENCE AL	1	0.45	92.38
90	TALLAHASSEE FL	1	0.45	92.83
91	LUBBOCK TX	1	0.44	93.27
92	TUSCALOOSA AL	1	0.43	93.71
93	COLUMBIA MO	1	0.43	94.14
94	MONROE LA	1	0.43	94.58
95	AMARILLO TX	1	0.43	95.00
96	ST CLOUD MN	1	0.41	95.42
97	KANKAKEE IL	1	0.39	95.80
98	SPOKANE WA	1	0.38	96.18
99	ENID OK	1	0.37	96.55
100	PUEBLO CO	1	0.36	96.91
101	BOISE CITY ID	1	0.36	97.26
102	RENO NV	1	0.34	97.60
103	BISMARK ND	1	0.33	97.93
104	BILLINGS MT	1	0.33	98.27
105	LAREDO TX	1	0.32	98.59
106	CASPER WY	1	0.31	98.90

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TABLE I-7. SUMMARY NETWORK OPTIMIZATION REPORT (CONTINUED)

	NO. SMSA'S	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
107 GREAT FALLS MT	1	0.30	99.20
108 MEDFORD OR	1	0.29	99.49
109 REDDING CA	1	0.27	99.76
110 BELLINGHAM WA	1	0.24	100.00

TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
1	NEW YORK NY-NJ				
1	ALLENTOWN-BETHLEHEM-EASTON PA-NJ	78			
2	BRIDGEPORT CT	52			
3	BRISTOL CT	85			
4	DANBURY CT	54			
5	JERSEY CITY NJ	3			
6	LONG BRANCH-ASBURY PARK NJ	31			
7	MERIDEN CT	83			
8	NASSAU-SUFFOLK NY	20			
9	NEW BRUNSWICK-PERTH AMBOY-SAYR N	30			
10	NEW HAVEN-WEST HAVEN CT	68			
11	NEW YORK NY-NJ	0			
12	NEWARK NJ	10			
13	NEWBRGH-MIDDLETOWN NY	55			
14	NORWALK CT	39			
15	PATERSON-CLIFTON-PASSAIC NJ	16			
16	PHILADELPHIA PA-NJ	82			
17	POUGHKEEPSIE NY	68			
18	STAMFORD CT	33			
19	TRENTON NJ	54			
20	WATERBURY CT	75			
2	CANTON OH			1.33	1.33
21	AKRON OH	21	0.13		
22	CANTON OH	0	0.12		
23	CLEVELAND OH	51	0.23		
24	MANSFIELD OH	60	0.09		
25	PITTSBURGH PA	77	0.28		
26	SHARON PA	55	0.11		
27	STEUBENVILLE-WEIRTON OH-WV	50	0.11		
28	WHEELING WV-OH	62	0.11	STEUBENVILLE-W	22
29	YOUNGSTOWN-WARREN OH	44	0.13		
3	RACINE WI			1.21	2.54
30	CHICAGO IL	59	0.70		
31	GARY-HAMMOND-EAST CHICAGO IN	81	0.12	CHICAGO IL	25
32	KENOSHA WI	10	0.09		
33	MILWAUKEE WI	24	0.21		
34	RACINE WI	0	0.09		
4	JACKSON MI			0.93	3.47
35	ANN ARBOR MI	38	0.09		

TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	36 BATTLE CREEK MI	40	0.09		
	37 DETROIT MI	70	0.43		
	38 JACKSON MI	0	0.09		
	39 KALAMAZOO-PORTAGE MI	60	0.10		
	40 LANSING-EAST LANSING MI	34	0.12		
5	SPRINGFIELD-CHICOPEE-HOLYOKE CT-MA			1.16	4.63
	41 BOSTON MA	81	0.27		
	42 BROCKTON MA	81	0.08	BOSTON MA	20
	43 FITCHBURG-LEOMINSTER MA	53	0.08		
	44 HARTFORD CT	24	0.10		
	45 LAWRENCE-HAVERHILL MA-NH	84	0.09	BOSTON MA	25
	46 LOWELL MA-NH	76	0.09	BOSTON MA	24
	47 NASHUA NH	74	0.08	FITCHBURG-LEOM	22
	48 NEW BRITAIN CT	33	0.06		
	49 NEW LONDON-NORWICH CT-RI	59	0.06		
	50 PITTSFIELD MA	42	0.06		
	51 SPRINGFIELD-CHICOPEE-HOLYOKE CT-	0	0.09		
	52 WORCESTER MA	42	0.09		
6	HAGERSTOWN MD			1.81	6.43
	53 BALTIMORE MD	64	0.36		
	54 CUMBERLAND MD-WV	55	0.18		
	55 HAGERSTOWN MD	0	0.10		
	56 HARRISBURG PA	62	0.14	YORK PA	23
	57 JOHNSTOWN PA	79	0.21		
	58 LANCASTER PA	81	0.11	YORK PA	23
	59 WASHINGTON DC-MD	64	0.59		
	60 YORK PA	58	0.11		
7	MUNCIE IN			1.15	7.58
	61 ANDERSON IN	18	0.13		
	62 DAYTON OH	70	0.22		
	63 INDIANAPOLIS IN	50	0.34		
	64 KOKOMO IN	44	0.14		
	65 MUNCIE IN	0	0.14		
	66 SPRINGFIELD OH	86	0.18	DAYTON OH	24
8	GREENSBORO-WINSTON-SALEM-HIGH NC			1.92	9.50
	67 BURLINGTON NC	20	0.28		
	68 CHARLOTTE-GASTONIA NC	84	0.33		

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TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	69 DANVILLE VA	42	0.22		
	70 GREENSBORO-WINSTON-SALEM-HIGH NC	0	0.34		
	71 RALEIGH-DURHAM NC	67	0.29		
	72 ROANOKE VA	83	0.23		
	73 SALISBURY-CONCORD NC	65	0.22		
9	ANNISTON AL			1.44	10.94
	74 ANNISTON AL	0	0.18		
	75 ATLANTA GA	84	0.57		
	76 BIRMINGHAM AL	58	0.30		
	77 GADSDEN AL	26	0.18		
	78 HUNTSVILLE AL	86	0.22		
10	SPRINGFIELD IL			1.36	12.30
	79 BLOOMINGTON-NORMAL IL	59	0.17		
	80 DECATUR IL	38	0.17		
	81 PEORIA IL	62	0.21		
	82 ST LOUIS MO-IL	86	0.61		
	83 SPRINGFIELD IL	0	0.20		
11	DUBUQUE IA			1.18	13.48
	84 DAVENPORT-ROCK ISLAND-MOLINE IA-	68	0.20		
	85 DUBUQUE IA	0	0.17		
	86 JANESVILLE-BELIOT WI	84	0.18	ROCKFORD IL	17
	87 MADISON WI	76	0.23		
	88 ROCKFORD IL	82	0.20		
	89 WATERLOO-CEDAR FALLS IA	86	0.20		
12	OXNARD-SIMI VALLEY-VENTURA CA			1.44	14.92
	90 ANAHEIM-SANTA ANA-GARDEN GROVE C	78	0.20	LOS ANGELES-LO	25
	91 LOS ANGELES-LONG BEACH CA	55	1.03		
	92 OXNARD-SIMI VALLEY-VENTURA CA	0	0.11		
	93 SANTA BARBARA-SANTA MARIA-LOMP C	34	0.10		
13	STOCKTON CA			1.42	16.34
	94 MODESTO CA	28	0.15		
	95 SACRAMENTO CA	45	0.22		
	96 SAN FRANCISCO-OAKLAND CA	63	0.49		

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TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	97 SAN JOSE CA	55	0.26		
	98 STOCKTON CA	0	0.15		
	99 VALLEJO-FAIRFIELD-NAPA CA	54	0.14		
14	PETERSBURG-COLONIAL HEIGHTS-HO VA			1.64	17.97
	100 CHARLOTTESVILLE VA	82	0.24		
	101 NEWPORT NEWS-HAMPTON VA	57	0.31		
	102 NORFOLK-VIRGINIA BEACH-PORTSMO V	67	0.41		
	103 PETERSBURG-COLONIAL HEIGHTS-HO V	0	0.25		
	104 RICHMOND VA	23	0.42		
15	LAKELAND-WINTER HAVEN FL			1.10	19.07
	105 LAKELAND-WINTER HAVEN FL	0	0.21		
	106 MELBOURNE-TITUSVILLE-COCOA FL	66	0.21		
	107 ORLANDO FL	42	0.29		
	108 TAMPA-ST PETERSBURG FL	46	0.39		
16	ELMIRA NY			1.67	20.74
	109 BINGHAMTON NY-PA	46	0.20		
	110 ELMIRA NY	0	0.16		
	111 NORTHEAST PENNSYLVANIA PA	76	0.26		
	112 ROCHESTER NY	85	0.58		
	113 SYRACUSE NY	74	0.31		
	114 WILLIAMSPORT PA	60	0.17		
17	LEXINGTON-FAYETTE KY			1.64	22.38
	115 CINCINNATI OH-KY	73	0.70		
	116 LEXINGTON-FAYETTE KY	0	0.38		
	117 LOUISVILLE KY-IN	70	0.57		
18	ROCHESTER MN			1.62	24.01
	118 EAU CLAIRE WI	72	0.25		
	119 LA CROSSE WI	63	0.21		
	120 MINNEAPOLIS-ST PAUL MN-WI	77	0.91		
	121 ROCHESTER MN	0	0.26		

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TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
19 ASHEVILLE NC			1.66	25.67
122 ANDERSON SC	76	0.28		
123 ASHEVILLE NC	0	0.31		
124 HICKORY NC	69	0.30		
125 JOHNSON CITY-KINGSPORT-BRISTOL T	52	0.38		
126 KNOXVILLE TN	81	0.39		
20 LIMA OH			1.59	27.25
127 COLUMBUS OH	79	0.60		
128 FORT WAYNE IN	59	0.31		
129 LIMA OH	0	0.26		
130 TOLEDO OH-MI	69	0.41		
21 BEAUMONT-PORT ARTHUR-ORANGE TX			1.58	28.83
131 BEAUMONT-PORT ARTHUR-ORANGE TX	0	0.24		
132 GALVESTON-TEXAS CITY TX	68	0.21		
133 HOUSTON TX	80	0.91		
134 LAKE CHARLES LA	55	0.22		
22 KANSAS CITY MO-KS			1.53	30.36
135 KANSAS CITY MO-KS	0	0.70		
136 LAWRENCE KS	37	0.26		
137 ST JOSEPH MO	48	0.27		
138 TOPEKA KS	59	0.30		
23 BENTON HARBOR MI			1.51	31.87
139 BENTON HARBOR MI	0	0.26		
140 ELKHART IN	39	0.25		
141 GRAND RAPIDS MI	71	0.41		
142 MUSKEGON-NORTON SHORES-MUSKEGO M	78	0.29		
143 SOUTH BEND IN	33	0.30		
24 BILOXI-GULFPORT MS			1.44	33.31
144 BILOXI-GULFPORT MS	0	0.26		
145 MOBILE AL	55	0.34		
146 NEW ORLEANS LA	78	0.57		
147 PASCAGOULA-MOSS POINT PATERSON M	21	0.26		

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TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
25 JACKSONVILLE NC			1.45	34.76
148 FAYETTEVILLE NC	86	0.37		
149 GREENVILLE-SPARTANBURG SC	60	0.45		
150 JACKSONVILLE NC	0	0.32		
151 WILMINGTON NC	47	0.32		
26 PARKERSBURG-MARIETTA WV-OH			1.46	36.22
152 CHARLESTON WV	64	0.42		
153 HUNTINGTON-ASHLAND WV-KY	76	0.37		
154 NEWARK OH	71	0.32		
155 PARKERSBURG-MARIETTA WV-OH	0	0.35		
27 COLUMBIA SC			1.46	37.68
156 AUGUSTA GA-SC	66	0.38		
157 COLUMBIA SC	0	0.45		
158 FLORENCE SC	74	0.32		
159 ROCK HILL SC	64	0.32		
28 DENVER-BOULDER CO			1.46	39.14
160 COLORADO SPRINGS CO	63	0.28		
161 DENVER-BOULDER CO	0	0.73		
162 FORT COLLINS CO	58	0.23		
163 GREELEY CO	50	0.22		
29 FORT LAUDERDALE-HOLLYWOOD FL			1.48	40.62
164 FORT LAUDERDALE-HOLLYWOOD FL	0	0.42		
165 MIAMI FL	24	0.71		
166 WEST PALM BEACH-BOCA RATON FL	40	0.35		
30 OCALA FL			1.44	42.05
167 DAYTONA BEACH FL	73	0.31		
168 GAINESVILLE FL	35	0.31		
169 JACKSONVILLE FL	84	0.53		
170 OCALA FL	0	0.28		

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TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
31 COLUMBUS GA-AL			1.41	43.46
171 ALBANY GA	78	0.31		
172 COLUMBUS GA-AL	0	0.37		
173 MACON GA	84	0.36		
174 MONTGOMERY AL	78	0.38		
32 DALLAS-FORT WORTH TX			1.37	44.83
175 DALLAS-FORT WORTH TX	0	1.10		
176 SHERMAN-DENISON TX	60	0.27		
33 PROVIDENCE-WARWICK-PAWTUCKET RI-MA			1.32	46.16
177 FALL RIVER MA-RI	16	0.26		
178 MANCHESTER NH	82	0.29		
179 NEW BEDFORD MA	29	0.28		
180 PROVIDENCE-WARWICK-PAWTUCKET RI-	0	0.49		
34 TERRE HAUTE IN			1.33	47.49
181 BLOOMINGTON IN	52	0.33		
182 CHAMPAIGN-URBANA-RANTOUL IL	64	0.34		
183 LAFAYETTE-WEST LAFAYETTE IN	71	0.31		
184 TERRE HAUTE IN	0	0.35		
35 BUFFALO NY			1.31	48.80
185 BUFFALO NY	0	0.86		
186 ERIE PA	81	0.45		
36 GLENS FALLS NY			1.34	50.14
187 ALBANY-SCHENECTADY-TROY NY	46	0.43		
188 BURLINGTON VT	85	0.35		
189 GLENS FALLS NY	0	0.26		
190 UTICA-ROME NY	81	0.29		

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TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
37	APPLETON-OSHKOSH WI			1.35	51.48
	191 APPLETON-OSHKOSH WI	0	0.37		
	192 GREEN BAY WI	27	0.35		
	193 SHEBOYGAN WI	49	0.32		
	194 WAUSAU WI	77	0.30		
38	BREMERTON WA			1.17	52.65
	195 BREMERTON WA	0	0.19		
	196 OLYMPIA WA	40	0.19		
	197 SEATTLE-EVERETT WA	15	0.54		
	198 TACOMA WA	24	0.26		
39	VINELAND-MILLVILLE-BRIDGETON NJ			1.31	53.96
	199 ATLANTIC CITY NJ	33	0.29		
	200 READING PA	76	0.33		
	201 VINELAND-MILLVILLE-BRIDGETON NJ	0	0.27		
	202 WILMINGTON DE-NJ	34	0.42		
40	LONGVIEW TX			1.28	55.24
	203 LONGVIEW TX	0	0.29		
	204 SHREVEPORT LA	58	0.39		
	205 TEXARKANA TX-AR	76	0.31		
	206 TYLER TX	35	0.29		
41	LAWTON OK			1.28	56.52
	207 LAWTON OK	0	0.30		
	208 OKLAHOMA CITY OK	78	0.68		
	209 WICHITA FALLS TX	49	0.30		
42	AUSTIN TX			1.29	57.81
	210 AUSTIN TX	0	0.44		
	211 KILLEEN-TEMPLE TX	59	0.29		
	212 SAN ANTONIO TX	73	0.55		
43	CLARKSVILLE-HOPKINSVILLE TN-KY			1.25	59.06

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TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	213 CLARKSVILLE-HOPKINSVILLE TN-KY	0	0.41		
	214 NASHVILLE-DAVIDSON TN	41	0.83		
44	BAY CITY MI			1.24	60.30
	215 BAY CITY MI	0	0.35		
	216 FLINT MI	42	0.49		
	217 SAGINAW MI	12	0.40		
45	JOPLIN MO			1.15	61.45
	218 FAYETTEVILLE-SPRINGDALE AR	73	0.37		
	219 JOPLIN MO	0	0.36		
	220 SPRINGFIELD MO	67	0.42		
46	LAFAYETTE LA			1.15	62.60
	221 ALEXANDRIA LA	79	0.33		
	222 BATON ROUGE LA	53	0.50		
	223 LAFAYETTE LA	0	0.33		
47	FORT WALTON BEACH FL			1.10	63.70
	224 FORT WALTON BEACH FL	0	0.34		
	225 PANAMA CITY FL	60	0.34		
	226 PENSACOLA FL	37	0.41		
48	LINCOLN NE			1.07	64.77
	227 LINCOLN NE	0	0.43		
	228 OMAHA NE-IA	50	0.64		
49	SALEM OR			1.00	65.77
	229 EUGENE-SPRINGFIELD OR	63	0.26		
	230 PORTLAND OR-WA	44	0.51		
	231 SALEM OR	0	0.24		

TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
50	BRADENTON FL			0.96	66.74
	232 BRADENTON FL	0	0.30		
	233 FORT MYERS FL	73	0.32		
	234 SARASOTA FL	11	0.34		
51	CHARLESTON-NORTH CHARLESTON SC			0.97	67.70
	235 CHARLESTON-NORTH CHARLESTON SC	0	0.53		
	236 SAVANNAH GA	84	0.44		
52	LITTLE ROCK-NORTH LITTLE ROCK AR			0.96	68.66
	237 LITTLE ROCK-NORTH LITTLE ROCK AR	0	0.59		
	238 PINE BLUFF AR	40	0.37		
53	EVANSVILLE IN-KY			0.93	69.59
	239 EVANSVILLE IN-KY	0	0.52		
	240 OWENSBORO KY	29	0.41		
54	MEMPHIS TN-AR			0.91	70.50
55	PROVO-OREM UT			0.85	71.35
	242 PROVO-OREM UT	0	0.29		
	243 SALT LAKE CITY-OGDEN UT	38	0.56		
56	VISALIA-TULARE-PORTERVILLE CA			0.78	72.13
	244 BAKERSFIELD CA	69	0.27		
	245 FRESNO CA	40	0.28		
	246 VISALIA-TULARE-PORTERVILLE CA	0	0.22		
57	PHOENIX AZ			0.78	72.91
58	CEDAR RAPIDS IA			0.76	73.67
	248 CEDAR RAPIDS IA	0	0.41		

TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	249 IOWA CITY IW	23	0.35		
59	LEWISTON-AUBURN ME			0.76	74.43
	250 LEWISTON-AUBURN ME	0	0.36		
	251 PORTLAND ME	31	0.41		
60	YUBA CITY CA			0.74	75.17
	252 CHICO CA	42	0.24		
	253 SANTA ROSA CA	76	0.27		
	254 YUBA CITY CA	0	0.23		
61	SAN DIEGO CA			0.75	75.92
62	SIOUX CITY NE-IA			0.74	76.67
	256 SIOUX CITY NE-IA	0	0.38		
	257 SIOUX FALLS SD	73	0.37		
63	BANGOR ME			0.74	77.40
	258 BANGOR ME	0	0.35		
	259 PORTSMOUTH-DOVER-ROCHESTER NH-ME	35	0.39		
64	TULSA OK			0.72	78.13
65	EL PASO TX			0.72	78.84
	261 EL PASO TX	0	0.43		
	262 LAS CRUCES NM	42	0.29		
66	FARGO-MOORHEAD ND-MN			0.70	79.54
	263 FARGO-MOORHEAD ND-MN	0	0.37		
	264 GRAND FORKS ND-MN	73	0.33		

TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
67 MIDLAND TX			0.68	80.21
265 MIDLAND TX	0	0.34		
266 ODESSA TX	21	0.34		
68 CORPUS CHRISTI TX			0.67	80.89
267 CORPUS CHRISTI TX	0	0.38		
268 VICTORIA TX	73	0.29		
69 ALTOONA PA			0.67	81.56
269 ALTOONA PA	0	0.35		
270 STATE COLLEGE PA	34	0.33		
70 BROWNSVILLE-HARLINGEN-SAN BENI TX			0.67	82.23
271 BROWNSVILLE-HARLINGEN-SAN BENI T	0	0.32		
272 MCALLEN-PHARR-EDINBURG TX	34	0.35		
71 BRYAN-COLLEGE STATION TX			0.66	82.89
273 BRYAN-COLLEGE STATION TX	0	0.31		
274 WACO TX	76	0.36		
72 ABILENE TX			0.66	83.55
275 ABILENE TX	0	0.35		
276 SAN ANGELO TX	80	0.31		
73 CHATTANOOGA TN-GA			0.64	84.19
74 DES MOINES IA			0.64	84.83
75 WICHITA KS			0.59	85.42
76 JACKSON MS			0.57	85.99

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TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
77	SALINAS-SEASIDE-MONTEREY CA			0.55	86.54
	281 SALINAS-SEASIDE-MONTEREY CA	0	0.29		
	282 SANTA CRUZ CA	30	0.27		
78	DULUTH-SUPERIOR MN-WI			0.52	87.06
79	RICHLAND-KENNEWICK WA			0.51	87.57
	284 RICHLAND-KENNEWICK WA	0	0.26		
	285 YAKIMA WA	63	0.26		
80	ALBUQUERQUE NM			0.51	88.08
81	RIVERSIDE-SAN BERNARDINO-ONTAR CA			0.51	88.59
82	HAMILTON-MIDDLETOWN OH			0.50	89.09
83	LORAIN-ELYRIA OH			0.48	89.57
84	LYNCHBURG VA			0.48	90.05
85	LAS VEGAS NV			0.48	90.52
86	TUCSON AZ			0.48	91.00
87	FORT SMITH AR-OK			0.48	91.48
88	ATHENS GE			0.45	91.93
89	FLORENCE AL			0.45	92.38
90	TALLAHASSEE FL			0.45	92.83
91	LUBBOCK TX			0.44	93.27

TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
92 TUSCALOOSA AL			0.43	93.71
93 COLUMBIA MO			0.43	94.14
94 MONROE LA			0.43	94.58
95 AMARILLO TX			0.43	95.00
96 ST CLOUD MN			0.41	95.42
97 KANKAKEE IL			0.39	95.80
98 SPOKANE WA			0.38	96.18
99 ENID OK			0.37	96.55
100 PUEBLO CO			0.36	96.91
101 BOISE CITY ID			0.36	97.26
102 RENO NV			0.34	97.60
103 BISMARK ND			0.33	97.93
104 BILLINGS MT			0.33	98.27
105 LAREDO TX			0.32	98.59
106 CASPER WY			0.31	98.90
107 GREAT FALLS MT			0.30	99.20
108 MEDFORD OR			0.29	99.49
109 REDDING CA			0.27	99.76

TABLE I-8. SPECIALIZED CARRIER NETWORK OPTIMIZATION REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
110 BELLINGHAM WA			0.24	100.00

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TABLE I-9. SUMMARY MOST EFFICIENT NETWORK REPORT

		NO. SMSA'S	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
1	NEW YORK NY-NJ	20	9.77	9.77
2	CANTON OH	9	3.85	13.62
3	RACINE WI	5	4.02	17.64
4	JACKSON MI	6	2.75	20.40
5	SPRINGFIELD-CHICOPEE-HOLYOKE CT-MA	12	3.17	23.56
6	HAGERSTOWN MD	8	3.56	27.12
7	MUNCIE IN	6	1.88	29.00
8	GREENSBORO-WINSTON-SALEM-HIGH NC	7	2.32	31.33
9	ANNISTON AL	5	2.15	33.48
10	SPRINGFIELD IL	5	2.00	35.48
11	DUBUQUE IA	6	1.47	36.95
12	OXNARD-SIMI VALLEY-VENTURA CA	4	2.83	39.78
13	STOCKTON CA	6	1.89	41.67
14	PETERSBURG-COLONIAL HEIGHTS-HO VA	5	1.63	43.30
15	LAKELAND-WINTER HAVEN FL	4	1.20	44.50
16	ELMIRA NY	6	1.68	46.18
17	LEXINGTON-FAYETTE KY	3	1.60	47.78
18	ROCHESTER MN	4	1.68	49.46
19	ASHEVILLE NC	5	1.41	50.87
20	LIMA OH	4	1.47	52.34
21	BEAUMONT-PORT ARTHUR-ORANGE TX	4	1.70	54.04
22	KANSAS CITY MO-KS	4	1.36	55.40
23	BENTON HARBOR MI	5	1.24	56.64
24	BILOXI-GULFPORT MS	4	1.25	57.89
25	JACKSONVILLE NC	4	1.07	58.96
26	PARKERSBURG-MARIETTA WV-OH	4	1.07	60.03
27	COLUMBIA SC	4	1.07	61.10
28	DENVER-BOULDER CO	4	1.31	62.41
29	FORT LAUDERDALE-HOLLYWOOD FL	3	1.21	63.62
30	OCALA FL	4	1.02	64.63
31	COLUMBUS GA-AL	4	0.98	65.61
32	DALLAS-FORT WORTH TX	2	1.13	66.74
33	PROVIDENCE-WARWICK-PAWTUCKET RI-MA	4	0.92	67.66
34	TERRE HAUTE IN	4	0.91	68.57
35	BUFFALO NY	2	0.87	69.45
36	GLENS FALLS NY	4	0.88	70.32
37	APPLETON-OSHKOSH WI	4	0.87	71.19
38	BREMERTON WA	4	0.85	72.04
39	VINELAND-MILLVILLE-BRIDGETON NJ	4	0.85	72.89
40	LONGVIEW TX	4	0.86	73.75
41	LAWTON OK	3	0.89	74.64
42	AUSTIN TX	3	0.89	75.53
43	CLARKSVILLE-HOPKINSVILLE TN-KY	2	0.78	76.30
44	BAY CITY MI	3	0.75	77.06
45	JOPLIN MO	3	0.70	77.75
46	LAFAYETTE LA	3	0.73	78.48
47	FORT WALTON BEACH FL	3	0.65	79.13
48	LINCOLN NE	2	0.67	79.80
49	SALEM OR	3	0.66	80.46
50	BRADENTON FL	3	0.56	81.02
51	CHARLESTON-NORTH CHARLESTON SC	2	0.55	81.57
52	LITTLE ROCK-NORTH LITTLE ROCK AR	2	0.56	82.13
53	EVANSVILLE IN-KY	2	0.53	82.66

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TABLE I-9. SUMMARY MOST EFFICIENT NETWORK REPORT (CONTINUED)

		NO. SMSA'S	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
54	MEMPHIS TN-AR	1	0.54	83.20
55	PROVO-OREM UT	2	0.54	83.74
56	VISALIA-TULARE-PORTERVILLE CA	3	0.48	84.22
57	PHOENIX AZ	1	0.50	84.72
58	CEDAR RAPIDS IA	2	0.43	85.15
59	LEWISTON-AUBURN ME	2	0.41	85.56
60	YUBA CITY CA	3	0.42	85.98
61	SAN DIEGO CA	1	0.47	86.45
62	SIOUX CITY NE-IA	2	0.41	86.86
63	BANGOR ME	2	0.39	87.25
64	TULSA OK	1	0.42	87.67
65	EL PASO TX	2	0.41	88.08
66	FARGO-MOORHEAD ND-MN	2	0.38	88.46
67	MIDLAND TX	2	0.37	88.83
68	CORPUS CHRISTI TX	2	0.37	89.19
69	ALTOONA PA	2	0.36	89.55
70	BROWNSVILLE-HARLINGEN-SAN BENI TX	2	0.37	89.92
71	BRYAN-COLLEGE STATION TX	2	0.36	90.28
72	ABILENE TX	2	0.35	90.63
73	CHATTANOOGA TN-GA	1	0.34	90.97
74	DES MOINES IA	1	0.35	91.32
75	WICHITA KS	1	0.32	91.64
76	JACKSON MS	1	0.30	91.94
77	SALINAS-SEASIDE-MONTEREY CA	2	0.30	92.24
78	DULUTH-SUPERIOR MN-WI	1	0.27	92.51
79	RICHLAND-KENNEWICK WA	2	0.27	92.78
80	ALBUQUERQUE NM	1	0.28	93.05
81	RIVERSIDE-SAN BERNARDINO-ONTAR CA	1	0.27	93.33
82	HAMILTON-MIDDLETOWN OH	1	0.26	93.58
83	LORAIN-ELYRIA OH	1	0.25	93.83
84	LYNCHBURG VA	1	0.25	94.08
85	LAS VEGAS NV	1	0.25	94.33
86	TUCSON AZ	1	0.25	94.58
87	FORT SMITH AR-OK	1	0.25	94.83
88	ATHENS GE	1	0.23	95.06
89	FLORENCE AL	1	0.23	95.29
90	TALLAHASSEE FL	1	0.23	95.52
91	LUBBOCK TX	1	0.23	95.74
92	TUSCALOOSA AL	1	0.22	95.96
93	COLUMBIA MO	1	0.22	96.18
94	MONROE LA	1	0.22	96.40
95	AMARILLO TX	1	0.22	96.62
96	ST CLOUD MN	1	0.21	96.83
97	KANKAKEE IL	1	0.20	97.03
98	SPOKANE WA	1	0.19	97.22
99	ENID OK	1	0.19	97.40
100	PUEBLO CO	1	0.18	97.58
101	BOISE CITY ID	1	0.18	97.76
102	RENO NV	1	0.17	97.93
103	BISMARK ND	1	0.17	98.10
104	BILLINGS MT	1	0.17	98.27

TABLE I-10. MOST EFFICIENT NETWORK REPORT

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
1	NEW YORK NY-NJ			9.77	9.77
	1 ALLENTOWN-BETHLEHEM-EASTON PA-NJ	78	0.29		
	2 BRIDGEPORT CT	52	0.29		
	3 BRISTOL CT	85	0.14		
	4 DANBURY CT	54	0.16		
	5 JERSEY CITY NJ	3	0.24		
	6 LONG BRANCH-ASBURY PARK NJ	31	0.23		
	7 MERIDEN CT	83	0.14		
	8 NASSAU-SUFFOLK NY	20	0.72		
	9 NEW BRUNSWICK-PERTH AMBOY-SAYR N	30	0.28		
	10 NEW HAVEN-WEST HAVEN CT	68	0.29		
	11 NEW YORK NY-NJ	0	3.72		
	12 NEWARK NJ	10	0.57		
	13 NEWBRGH-MIDDLETOWN NY	55	0.18		
	14 NORWALK CT	39	0.16		
	15 PATERSON-CLIFTON-PASSAIC NJ	16	0.21		
	16 PHILADELPHIA PA-NJ	82	1.38		
	17 POUGHKEEPSIE NY	68	0.18		
	18 STAMFORD CT	33	0.19		
	19 TRENTON NJ	54	0.23		
	20 WATERBURY CT	75	0.17		
2	CANTON OH			3.85	13.62
	21 AKRON OH	21	0.40		
	22 CANTON OH	0	0.31		
	23 CLEVELAND OH	51	0.91		
	24 MANSFIELD OH	60	0.23		
	25 PITTSBURGH PA	77	0.95		
	26 SHARON PA	55	0.24		
	27 STEUBENVILLE-WEIRTON OH-WV	50	0.24		
	28 WHEELING WV-OH	62	0.24	STEUBENVILLE-W	22
	29 YOUNGSTOWN-WARREN OH	44	0.33		
3	RACINE WI			4.02	17.64
	30 CHICAGO IL	59	2.62		
	31 GARY-HAMMOND-EAST CHICAGO IN	81	0.29	CHICAGO IL	25
	32 KENOSHA WI	10	0.20		
	33 MILWAUKEE WI	24	0.69		
	34 RACINE WI	0	0.22		
4	JACKSON MI			2.75	20.40
	35 ANN ARBOR MI	38	0.26		

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TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	36 BATTLE CREEK MI	40	0.21		
	37 DETROIT MI	70	1.48		
	38 JACKSON MI	0	0.21		
	39 KALAMAZOO-PORTAGE MI	60	0.24		
	40 LANSING-EAST LANSING MI	34	0.34		
5	SPRINGFIELD-CHICOPEE-HOLYOKE CT-MA			3.17	23.56
	41 BOSTON MA	81	0.93		
	42 BROCKTON MA	81	0.17	BOSTON MA	20
	43 FITCHBURG-LEOMINSTER MA	53	0.16		
	44 HARTFORD CT	24	0.35		
	45 LAWRENCE-HAVERHILL MA-NH	84	0.20	BOSTON MA	25
	46 LOWELL MA-NH	76	0.19	BOSTON MA	24
	47 NASHUA NH	74	0.17	FITCHBURG-LEOM	22
	48 NEW BRITAIN CT	33	0.16		
	49 NEW LONDON-NORWICH CT-RI	59	0.19		
	50 PITTSFIELD MA	42	0.15		
	51 SPRINGFIELD-CHICOPEE-HOLYOKE CT-	0	0.27		
	52 WORCESTER MA	42	0.23		
6	HAGERSTOWN MD			3.56	27.12
	53 BALTIMORE MD	64	0.86		
	54 CUMBERLAND MD-WV	55	0.22		
	55 HAGERSTOWN MD	0	0.18		
	56 HARRISBURG PA	62	0.29	YORK PA	23
	57 JOHNSTOWN PA	79	0.27		
	58 LANCASTER PA	81	0.22	YORK PA	23
	59 WASHINGTON DC-MD	64	1.30		
	60 YORK PA	58	0.22		
7	MUNCIE IN			1.88	29.00
	61 ANDERSON IN	18	0.20		
	62 DAYTON OH	70	0.42		
	63 INDIANAPOLIS IN	50	0.62		
	64 KOKOMO IN	44	0.20		
	65 MUNCIE IN	0	0.21		
	66 SPRINGFIELD OH	86	0.23	DAYTON OH	24
8	GREENSBORO-WINSTON-SALEM-HIGH NC			2.32	31.33
	67 BURLINGTON NC	20	0.32		
	68 CHARLOTTE-GASTONIA NC	84	0.45		

TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	69 DANVILLE VA	42	0.23		
	70 GREENSBORO-WINSTON-SALEM-HIGH NC	0	0.43		
	71 RALEIGH-DURHAM NC	67	0.37		
	72 ROANOKE VA	83	0.27		
	73 SALISBURY-CONCORD NC	65	0.25		
9	ANNISTON AL			2.15	33.48
	74 ANNISTON AL	0	0.22		
	75 ATLANTA GA	84	0.94		
	76 BIRMINGHAM AL	58	0.48		
	77 GADSDEN AL	26	0.22		
	78 HUNTSVILLE AL	86	0.30		
10	SPRINGFIELD IL			2.00	35.48
	79 BLOOMINGTON-NORMAL IL	59	0.21		
	80 DECATUR IL	38	0.22		
	81 PEORIA IL	62	0.30		
	82 ST LOUIS MO-IL	86	1.00		
	83 SPRINGFIELD IL	0	0.27		
11	DUBUQUE IA			1.47	36.95
	84 DAVENPORT-ROCK ISLAND-MOLINE IA-	68	0.28		
	85 DUBUQUE IA	0	0.20		
	86 JANESVILLE-BELIOT WI	84	0.21	ROCKFORD IL	17
	87 MADISON WI	76	0.30		
	88 ROCKFORD IL	82	0.26		
	89 WATERLOO-CEDAR FALLS IA	86	0.22		
12	OXNARD-SIMI VALLEY-VENTURA CA			2.83	39.78
	90 ANAHEIM-SANTA ANA-GARDEN GROVE C	78	0.36	LOS ANGELES-LO	25
	91 LOS ANGELES-LONG BEACH CA	55	2.15		
	92 OXNARD-SIMI VALLEY-VENTURA CA	0	0.17		
	93 SANTA BARBARA-SANTA MARIA-LOMP C	34	0.16		
13	STOCKTON CA			1.89	41.67
	94 MODESTO CA	28	0.16		
	95 SACRAMENTO CA	45	0.30		
	96 SAN FRANCISCO-OAKLAND CA	63	0.76		

TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

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		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	97 SAN JOSE CA	55	0.35		
	98 STOCKTON CA	0	0.17		
	99 VALLEJO-FAIRFIELD-NAPA CA	54	0.15		
14	PETERSBURG-COLONIAL HEIGHTS-HO VA			1.63	43.30
	100 CHARLOTTESVILLE VA	82	0.22		
	101 NEWPORT NEWS-HAMPTON VA	57	0.31		
	102 NORFOLK-VIRGINIA BEACH-PORTSMO V	67	0.44		
	103 PETERSBURG-COLONIAL HEIGHTS-HO V	0	0.22		
	104 RICHMOND VA	23	0.44		
15	LAKELAND-WINTER HAVEN FL			1.20	44.50
	105 LAKELAND-WINTER HAVEN FL	0	0.21		
	106 MELBOURNE-TITUSVILLE-COCOA FL	66	0.21		
	107 ORLANDO FL	42	0.32		
	108 TAMPA-ST PETERSBURG FL	46	0.47		
16	ELMIRA NY			1.68	46.18
	109 BINGHAMTON NY-PA	46	0.20		
	110 ELMIRA NY	0	0.16		
	111 NORTHEAST PENNSYLVANIA PA	76	0.30		
	112 ROCHESTER NY	85	0.52		
	113 SYRACUSE NY	74	0.32		
	114 WILLIAMSPORT PA	60	0.17		
17	LEXINGTON-FAYETTE KY			1.60	47.78
	115 CINCINNATI OH-KY	73	0.72		
	116 LEXINGTON-FAYETTE KY	0	0.32		
	117 LOUISVILLE KY-IN	70	0.56		
18	ROCHESTER MN			1.68	49.46
	118 EAU CLAIRE WI	72	0.21		
	119 LA CROSSE WI	63	0.19		
	120 MINNEAPOLIS-ST PAUL MN-WI	77	1.06		
	121 ROCHESTER MN	0	0.22		

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TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
19 ASHEVILLE NC			1.41	50.87
122 ANDERSON SC	76	0.23		
123 ASHEVILLE NC	0	0.25		
124 HICKORY NC	69	0.24		
125 JOHNSON CITY-KINGSPORT-BRISTO[illegible]	52	0.33		
126 KNOXVILLE TN	81	0.36		
20 LIMA OH			1.47	52.34
127 COLUMBUS OH	79	0.58		
128 FORT WAYNE IN	59	0.29		
129 LIMA OH	0	0.22		
130 TOLEDO OH-MI	69	0.38		
21 BEAUMONT-PORT ARTHUR-ORANGE TX			1.70	54.04
131 BEAUMONT-PORT ARTHUR-ORANGE TX	0	0.23		
132 GALVESTON-TEXAS CITY TX	68	0.19		
133 HOUSTON TX	80	1.09		
134 LAKE CHARLES LA	55	0.20		
22 KANSAS CITY MO-KS			1.36	55.40
135 KANSAS CITY MO-KS	0	0.69		
136 LAWRENCE KS	37	0.20		
137 ST JOSEPH MO	48	0.21		
138 TOPEKA KS	59	0.25		
23 BENTON HARBOR MI			1.24	56.64
139 BENTON HARBOR MI	0	0.21		
140 ELKHART IN	39	0.20		
141 GRAND RAPIDS MI	71	0.36		
142 MUSKEGON-NORTON SHORES-MUSKEGO M	78	0.22		
143 SOUTH BEND IN	33	0.25		
24 BILOXI-GULFPORT MS			1.25	57.89
144 BILOXI-GULFPORT MS	0	0.21		
145 MOBILE AL	55	0.29		
146 NEW ORLEANS LA	78	0.56		
147 PASCAGOULA-MOSS POINT PATERSON M	21	0.20		

TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
25 JACKSONVILLE NC			1.07	58.96
148 FAYETTEVILLE NC	86	0.27		
149 GREENVILLE-SPARTANBURG SC	60	0.35		
150 JACKSONVILLE NC	0	0.22		
151 WILMINGTON NC	47	0.22		
26 PARKERSBURG-MARIETTA WV-OH			1.07	60.03
152 CHARLESTON WV	64	0.31		
153 HUNTINGTON-ASHLAND WV-KY	76	0.28		
154 NEWARK OH	71	0.23		
155 PARKERSBURG-MARIETTA WV-OH	0	0.25		
27 COLUMBIA SC			1.07	61.10
156 AUGUSTA GA-SC	66	0.28		
157 COLUMBIA SC	0	0.35		
158 FORENCE SC	74	0.22		
159 ROCK HILL SC	64	0.22		
28 DENVER-BOULDER CO			1.31	62.41
160 COLORADO SPRINGS CO	63	0.24		
161 DENVER-BOULDER CO	0	0.72		
162 FORT COLLINS CO	58	0.18		
163 GREELEY CO	50	0.17		
29 FORT LAUDERDALE-HOLLYWOOD FL			1.21	63.62
164 FORT LAUDERDALE-HOLLYWOOD FL	0	0.33		
165 MIAMI FL	24	0.61		
166 WEST PALM BEACH-BOCA RATON FL	40	0.26		
30 OCALA FL			1.02	64.63
167 DAYTONA BEACH FL	73	0.22		
168 GAINESVILLE FL	35	0.21		
169 JACKSONVILLE FL	84	0.39		
170 OCALA FL	0	0.19		

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TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
31	COLUMBUS GA-AL			0.98	65.61
	171 ALBANY GA	78	0.21		
	172 COLUMBUS GA-AL	0	0.26		
	173 MACON GA	84	0.25		
	174 MONTGOMERY AL	78	0.27		
32	DALLAS-FORT WORTH TX			1.13	66.74
	175 DALLAS-FORT WORTH TX	0	0.95		
	176 SHERMAN-DENISON TX	60	0.19		
33	PROVIDENCE-WARWICK-PAWTUCKET RI-MA			0.92	67.66
	177 FALL RIVER MA-RI	16	0.17		
	178 MANCHESTER NH	82	0.20		
	179 NEW BEDFORD MA	29	0.19		
	180 PROVIDENCE-WARWICK-PAWTUCKET RI-	0	0.36		
34	TERRE HAUTE IN			0.91	68.57
	181 BLOOMINGTON IN	52	0.22		
	182 CHAMPAIGN-URBANA-RANTOUL IL	64	0.24		
	183 LAFAYETTE-WEST LAFAYETTE IN	71	0.22		
	184 TERRE HAUTE IN	0	0.23		
35	BUFFALO NY			0.87	69.45
	185 BUFFALO NY	0	0.59		
	186 ERIE PA	81	0.29		
36	GLENS FALLS NY			0.88	70.32
	187 ALBANY-SCHENECTADY-TROY NY	46	0.31		
	188 BURLINGTON VT	85	0.21		
	189 GLENS FALLS NY	0	0.17		
	190 UTICA-ROME NY	81	0.20		

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TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
37	APPLETON-OSHKOSH WI			0.87	71.19
	191 APPLETON-OSHKOSH WI	0	0.24		
	192 GREEN BAY WI	27	0.23		
	193 SHEBOYGAN WI	49	0.20		
	194 WAUSAU WI	77	0.20		
38	BREMERTON WA			0.85	72.04
	195 BREMERTON WA	0	0.13		
	196 OLYMPIA WA	40	0.12		
	197 SEATTLE-EVERETT WA	15	0.42		
	198 TACOMA WA	24	0.18		
39	VINELAND-MILLVILLE-BRIDGETON NJ			0.85	72.89
	199 ATLANTIC CITY NJ	33	0.18		
	200 READING PA	76	0.22		
	201 VINELAND-MILLVILLE-BRIDGETON NJ	0	0.17		
	202 WILMINGTON DE-NJ	34	0.28		
40	LONGVIEW TX			0.86	73.75
	203 LONGVIEW TX	0	0.20		
	204 SHREVEPORT LA	58	0.27		
	205 TEXARKANA TX-AR	76	0.21		
	206 TYLER TX	35	0.19		
41	LAWTON OK			0.89	74.64
	207 LAWTON OK	0	0.19		
	208 OKLAHOMA CITY OK	78	0.49		
	209 WICHITA FALLS TX	49	0.20		
42	AUSTIN TX			0.89	75.53
	210 AUSTIN TX	0	0.31		
	211 KILLEEN-TEMPLE TX	59	0.20		
	212 SAN ANTONIO TX	73	0.38		
43	CLARKSVILLE-HOPKINSVILLE TN-KY			0.78	76.30

TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	213 CLARKSVILLE-HOPKINSVILLE TN-KY	0	0.24		
	214 NASHVILLE-DAVIDSON TN	41	0.53		
44	BAY CITY MI			0.75	77.06
	215 BAY CITY MI	0	0.21		
	216 FLINT MI	42	0.30		
	217 SAGINAW MI	12	0.24		
45	JOPLIN MO			0.70	77.75
	218 FAYETTEVILLE-SPRINGDALE AR	73	0.23		
	219 JOPLIN MO	0	0.22		
	220 SPRINGFIELD MO	67	0.25		
46	LAFAYETTE LA			0.73	78.48
	221 ALEXANDRIA LA	79	0.20		
	222 BATON ROUGE LA	53	0.32		
	223 LAFAYETTE LA	0	0.21		
47	FORT WALTON BEACH FL			0.65	79.13
	224 FORT WALTON BEACH FL	0	0.20		
	225 PANAMA CITY FL	60	0.20		
	226 PENSACOLA FL	37	0.25		
48	LINCOLN NE			0.67	79.80
	227 LINCOLN NE	0	0.26		
	228 OMAHA NE-IA	50	0.40		
49	SALEM OR			0.66	80.46
	229 EUGENE-SPRINGFIELD OR	63	0.17		
	230 PORTLAND OR-WA	44	0.35		
	231 SALEM OR	0	0.15		

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TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
50 BRADENTON FL			0.56	81.02
232 BRADENTON FL	0	0.18		
233 FORT MYERS FL	73	0.18		
234 SARASOTA FL	11	0.20		
51 CHARLESTON-NORTH CHARLESTON SC			0.55	81.57
235 CHARLESTON-NORTH CHARLESTON SC	0	0.31		
236 SAVANNAH GA	84	0.25		
52 LITTLE ROCK-NORTH LITTLE ROCK AR			0.56	82.13
237 LITTLE ROCK-NORTH LITTLE ROCK AR	0	0.35		
238 PINE BLUFF AR	40	0.21		
53 EVANSVILLE IN-KY			0.53	82.66
239 EVANSVILLE IN-KY	0	0.30		
240 OWENSBORO KY	29	0.23		
54 MEMPHIS TN-AR			0.54	83.20
55 PROVO-OREM UT			0.54	83.74
242 PROVO-OREM UT	0	0.18		
243 SALT LAKE CITY-OGDEN UT	38	0.36		
56 VISALIA-TULARE-PORTERVILLE CA			0.48	84.22
244 BAKERSFIELD CA	69	0.17		
245 FRESNO CA	40	0.18		
246 VISALIA-TULARE-PORTERVILLE CA	0	0.14		
57 PHOENIX AZ			0.50	84.72
58 CEDAR RAPIDS IA			0.43	85.15
248 CEDAR RAPIDS IA	0	0.23		

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TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
	249 IOWA CITY IW	23	0.19		
59	LEWISTON-AUBURN ME			0.41	85.56
	250 LEWISTON-AUBURN ME	0	0.19		
	251 PORTLAND ME	31	0.22		
60	YUBA CITY CA			0.42	85.98
	252 CHICO CA	42	0.14		
	253 SANTA ROSA CA	76	0.15		
	254 YUBA CITY CA	0	0.13		
61	SAN DIEGO CA			0.47	86.45
62	SIOUX CITY NE-IA			0.41	86.86
	256 SIOUX CITY NE-IA	0	0.21		
	257 SIOUX FALLS SD	73	0.20		
63	BANGOR ME			0.39	87.25
	258 BANGOR ME	0	0.18		
	259 PORTSMOUTH-DOVER-ROCHESTER NH-ME	35	0.21		
64	TULSA OK			0.42	87.67
65	EL PASO TX			0.41	88.08
	261 EL PASO TX	0	0.25		
	262 LAS CRUCES NM	42	0.16		
66	FARGO-MOORHEAD ND-MN			0.38	88.46
	263 FARGO-MOORHEAD ND-MN	0	0.20		
	264 GRAND FORKS ND-MN	73	0.18		

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TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
67 MIDLAND TX			0.37	88.83
265 MIDLAND TX	0	0.18		
266 ODESSA TX	21	0.19		
68 CORPUS CHRISTI TX			0.37	89.19
267 CORPUS CHRISTI TX	0	0.21		
268 VICTORIA TX	73	0.16		
69 ALTOONA PA			0.36	89.55
269 ALTOONA PA	0	0.18		
270 STATE COLLEGE PA	34	0.17		
70 BROWNSVILLE-HARLINGEN-SAN BENI TX			0.37	89.92
271 BROWNSVILLE-HARLINGEN-SAN BENI T	0	0.17		
272 MCALLEN-PHARR-EDINBURG TX	34	0.19		
71 BRYAN-COLLEGE STATION TX			0.36	90.28
273 BRYAN-COLLEGE STATION TX	0	0.17		
274 WACO TX	76	0.19		
72 ABILENE TX			0.35	90.63
275 ABILENE TX	0	0.19		
276 SAN ANGELO TX	80	0.17		
73 CHATTANOOGA TN-GA			0.34	90.97
74 DES MOINES IA			0.35	91.32
75 WICHITA KS			0.32	91.64
76 JACKSON MS			0.30	91.94

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TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

		DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
77	SALINAS-SEASIDE-MONTEREY CA			0.30	92.24
	281 SALINAS-SEASIDE-MONTEREY CA	0	0.15		
	282 SANTA CRUZ CA	30	0.14		
78	DULUTH-SUPERIOR MN-WI			0.27	92.51
79	RICHLAND-KENNEWICK WA			0.27	92.78
	284 RICHLAND-KENNEWICK WA	0	0.14		
	285 YAKIMA WA	63	0.14		
80	ALBUQUERQUE NM			0.28	93.05
81	RIVERSIDE-SAN BERNARDINO-ONTAR CA			0.27	93.33
82	HAMILTON-MIDDLETOWN OH			0.26	93.58
83	LORAIN-ELYRIA OH			0.25	93.83
84	LYNCHBURG VA			0.25	94.08
85	LAS VEGAS NV			0.25	94.33
86	TUCSON AZ			0.25	94.58
87	FORT SMITH AR-OK			0.25	94.83
88	ATHENS GE			0.23	95.06
89	FLORENCE AL			0.23	95.29
90	TALLAHASSEE FL			0.23	95.52
91	LUBBOCK TX			0.23	95.74

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TABLE I-10. MOST EFFICIENT NETWORK REPORT (CONTINUED)

	DISTANCE	INDIV MARKET VALUE	GROUP MARKET VALUE	CUM GROUP MARKET VALUE
92 TUSCALOOSA AL			0.22	95.96
93 COLUMBIA MO			0.22	96.18
94 MONROE LA			0.22	96.40
95 AMARILLO TX			0.22	96.62
96 ST CLOUD MN			0.21	96.83
97 KANKAKEE IL			0.20	97.03
98 SPOKANE WA			0.19	97.22
99 ENID OK			0.19	97.40
100 PUEBLO CO			0.18	97.58
101 BOISE CITY ID			0.18	97.76
102 RENO NV			0.17	97.93
103 BISMARK ND			0.17	98.10
104 BILLINGS MT			0.17	98.27